Contract Number W9132T-04-R-BAA1

ReliOn, Inc.

# Final Project Report

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells at Government Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY04

Prepared By
Russell Neff
ReliOn, Inc.
Spokane, Washington

Site 4-1 – U.S. Border Patrol Repeater Station, Mica Peak, Washington
Site 4-2 – U.S. Border Patrol Sector Head Quarters, Spokane, Washington

August 29, 2007

## Executive Summary

The two CERL fuel cell installations in the Spokane, Washington region were demonstration sites funded under the CERL-BAA-FY04 program (CERL4).

The project in Spokane consisted of two individual installation sites – **Site 1: Mica Peak** and **Site 2: Border Patrol Sector Headquarters.**

This project tested the reliability of the ReliOn® backup power fuel cell solution for U.S. Boarder Patrol microwave and radio repeater systems. The fuel cell systems were connected to a 24V DC bus at each site. The fuel cell systems were configured to monitor the commercial AC power grid as well as the status of the existing DC backup batteries at each site. Upon loss of AC power or low battery bus voltage, the fuel cells started automatically to provide up to 96 kWh of continuous run time at Site 1 - Mica Peak and 48 kWh of continuous run time at Site 2 - Sector Headquarters to critical equipment at their respective sites. In addition to providing continuous protection from a primary power failure, the installation was designed to simulate a 1-hour power failure of the AC grid each day. Data was collected concerning start-up times, power availability, shutdown capability, system efficiencies, load following, and the effects of varying environmental conditions. If the system failed to start up properly or provide required power to the load, this was noted in the logs as a failure and counts against the target 90% reliability and availability of the system.

These turn-key packages incorporate ReliOn's air cooled, cartridge-based, hydrogen-fueled PEM fuel cells operating in a grid-independent mode. The fuel cell systems were and remain housed in ReliOn's Outdoor Enclosure, which also provided the fuel storage and delivery system. This configuration allowed for ease of installation as the entire self-contained solution at both sites were placed on concrete pads and conduit was run to the DC bus. Because ReliOn's fuel cells operate at a relatively low temperature, cogeneration is not a part of this installation. Fuel switching is not required as the I-1000® runs on standard industrial grade hydrogen (99.95% purity), which is readily available.

Through the end of the 1-year test program, there were a total of 366 starts and 365.02 hours of run time at Site 1, Mica Peak. At Site 2, Border Patrol Sector Head Quarters, there were a total of 362 starts and 366.8 hours of run time.

In addition to the daily test runs, the ReliOn Fuel Cell systems at these sites maintained critical equipment functionality over two primary power outages totaling 4 hours, 46 minutes and 13 seconds during the demonstration period. At Site 1, Mica Peak, there was one primary power outage period of 1 minute, 13 seconds. At Site 2, Border Patrol Sector Head Quarters, the duration of the primary power outage was 4 hours, 45 minutes. According to CERL reporting requirements, overall reliability and availability calculations in this project have been based on total system performance, including special test equipment (computers, modems, PLC controllers) **that is not part of ReliOn's commercial fuel cell product line.**

The cumulative reliability for the entire 1-year demonstration program at Site 1, Mica Peak was 100% and cumulative availability was 100 percent. At Site 2, Border Patrol Sector Head Quarters both fuel cells were inadvertently disabled by an operator during a systems check in January of 2007. This human error resulted in the fuel cell systems not being available to perform the daily test for three days. Because of the operator error, the cumulative reliability for the demonstration program at Site 2, Border Patrol Sector Head Quarters was 99.2% and cumulative availability was 99.2% for the entire 1-year demonstration period. Had the operator properly placed the system in a "remote" start status, cumulative reliability and cumulative availability would have been 100% at Site 2, Border Patrol Sector Head Quarters. It should be noted that while the test involved the I-1000® fuel cell system, ReliOn's latest T-Series fuel cell design has control features that would not allow the operator error that occurred in this test program.

At the conclusion of the demonstration test program, and at the request of this site host, the fuel cell systems were converted to standard commercial installations (no longer in demonstration mode) and have become part of the equipment under the support of U.S. Customs and Border Protection.

Key contact personnel at the host site are as follows:

Mr. Rick Henderson<br>
Customs and Border Protection, Office of Information Technology<br>
U.S Customs and Border Protection Sector Headquarters, Spokane, Washington.<br>
Voice: (509) 353-2747<br>
Fax: (509) 353-2736<br>
Email: rick.henderson@dhs.gov

## Table of Contents

## 1.0 Descriptive Title

Field testing the performance and benefits of ReliOn's modular fuel cell-based backup power solutions on a critical application for the Department of Homeland Security, U.S. Customs and Border Protection at Mica Peak, near Spokane, Washington and U.S. Border Patrol Sector Head Quarters, Spokane, Washington.

## 2.0 Name, Address and Related Company Information

| | |
|---|---|
| ReliOn, Inc. | DUNS #: 137264193 |
| 15913 East Euclid | CAGE Code: 3K7Y7 |
| Spokane, WA 99216 | TIN: 912191190 |
| (509) 228-6500 | |

ReliOn, Inc., a privately held, small business, headquartered in Spokane, Washington, manufactures and markets proton exchange membrane (PEM) fuel cell products based on a unique and patented modular design. The company's current focus is on the sale and installation of highly reliable backup power solutions for critical applications within the telecom, utility and government/military markets.

ReliOn's offering helps customers increase network reliability while reducing overall equipment life-cycle costs in stationary, low power applications, typically requiring 200 watts to 12 kilowatts. Our air-cooled, self-hydrating fuel cells are highly reliable because we require only a minimal balance of plant and are able to bypass potential failure points.

ReliOn, formerly Avista Labs, has been developing, demonstrating and marketing PEM fuel cell technology for the past 11 years.

## 3.0 Production Capability of the Manufacturer

ReliOn, Inc., as described above, was the supplier and integrator of the primary products that comprise the backup power solution. These products are the I-1000®, 1kW fuel cell systems, and the Outdoor Enclosure System which is designed to house the fuel cells, hydrogen fuel and fuel delivery system. ReliOn was responsible for installation and commissioning of the backup power solution and performed all maintenance requirements via the company's Applications Engineers.

ReliOn's fuel cells are made from common materials using mature manufacturing processes in injection molded plastic, sheet metal fabrication and printed circuit board assembly. The membrane electrode assemblies (MEA) are purchased.

ReliOn manufactures certain components internally and utilized contract manufacturers. Production capacity is accommodated though internal and external sources.

The Outdoor Enclosure Systems installed at both U.S. Border Patrol communication sites were assembled and checked out in ReliOn's manufacturing area at its Spokane headquarters. This allowed integration and operational verification of special test instrumentation used in the CERL demonstration program.

## 4.0 Principal Investigator(s)

Mr. Russell Neff
Applications Engineer
ReliOn, Inc.
Voice: 509-228-6578
Fax: 509-228-6510
E-Mail: rneff@relion-inc.com

## 5.0 Authorized Negotiator(s)

Mr. Frank A. Ignazzitto
Vice President, Government Sales
ReliOn, Inc.
Voice: 703-431-4858
Fax: 509-228-6506
E-Mail: fignazzitto@relion-inc.com

Mr. Joe Blanchard
Vice President, Product Line Management
ReliOn, Inc.
Voice: 509-228-6570
Fax: 509-228-6510
E-Mail: jblanchard@relion-inc.com

## 6.0 Past Relevant Performance Information

ReliOn currently has sold more than 850 kW of fuel cell systems in government and commercial applications covering four continents. ReliOn's I-1000® fuel cell systems and backup power solutions have achieved numerous safety and performance certifications including; CSA, CE and NEBS Level III (telecom). ReliOn's next generation fuel cell systems—the T-1000® and T-2000™ are certified under UL in addition to CSA, CE and NEBS Level III (telecom).

Our experience is inclusive of the following installations:

- **The Federal Aviation Administration;**
  - Palwaukee, IL, Radio Transmitter Receiver, December, 2003
  - Swinns Valley, WI, Microwave, June, 2004
  - Wakeman, OH, Microwave, August, 2004
  - Fargo, ND, RCAG, September, 2004
  - Average turn-key cost was approximately $35,000
  - Contacts; Mr. Stanley Lee, General Engineer, 847-294-8457; stanley.lee@faa.gov
    Mr. Steve Aldridge, Environmental Engineer, 952-997-9264;
    steve.aldridge@faa.gov

- **The Bureau of Reclamation;**
  - Loveland, CO, Microwave, October, 2003
  - System cost was approximately $15,000
  - Contact; Mr. Nathan Myers, Electrical Engineer, 303-445-2633
    nmyers@do.usbr.gov

- **The States of Maryland and Ohio;**
  - 2 Sites in MD, 4 Sites in OH
  - E-911 radio equipment, August 2003 to October, 2004
  - Average turn-key cost was approximately $30,000 (no outdoor enclosure)
  - Contact; ReliOn, Inc, 509-228-6500
    www.relion-inc.com

In addition, ReliOn Fuel Cell Systems are installed in numerous commercial deployments as well as in field trials.

## 7.0 Host Site Information

Key contact personnel at U.S. Customs and Border Protection are as follows:

Mr. Rick Henderson
Customs and Border Protection, Office of Information Technology
U.S Customs and Border Protection Sector Headquarters, Spokane, Washington
Voice: (509) 353-2747
Fax: (509) 353-2736
Email: rick.henderson@dhs.gov

### Site 1--Mica Peak, near Spokane, Washington:

The Mica Peak application is a U.S Customs and Border Protection microwave and radio repeater station, and is located approximately 25 miles southeast of Spokane, Washington. The Mica Peak station is at an elevation of approximately 5225 feet. This site contains 10 Motorola Quantar radios, all powered with 110/120 VAC from the grid. Average transmit duty is 10-15%.

The station also includes a Monitron remote surveillance sensor and two microwave repeaters with a constant draw of 4.25 Amps each at 24 VDC. These repeaters are powered from an existing 24 VDC lead-acid battery string. The batteries are charged from a 25 Amp/24 Volt rectifier with a float voltage of 27.2 V. The Mica Peak station also has an existing 5 kW propane generator for site back-up power but that generator is no longer being used for any purpose. The ReliOn® fuel cell system will remain as the primary back-up power source.

### Site 2--Sector HQ Office Site – U.S Customs and Border Protection Sector Headquarters, Spokane, Washington:

The Border Patrol maintains a 100 Watt microwave repeater station and two GE Hi Band radio base stations at the Sector Headquarters building located at 10710 N. Newport Highway in Spokane. Currently, only one radio is in use. The second radio has been switched off and is being held in reserve. The Spokane Sector Headquarters is at an elevation of approximately 1900 feet. The two microwave repeaters with a constant draw of 4.25 Amps each at 24 VDC. These repeaters are powered from an existing 24 VDC lead-acid battery string. The batteries are charged from a 25 Amp/24 Volt rectifier with a float voltage of 27.2 V. The radio base stations are powered directly from the commercial grid at 110/120 VAC and draw 560 W each on transmit. Average transmit duty is 10-15%. There is no back-up generator at the station.

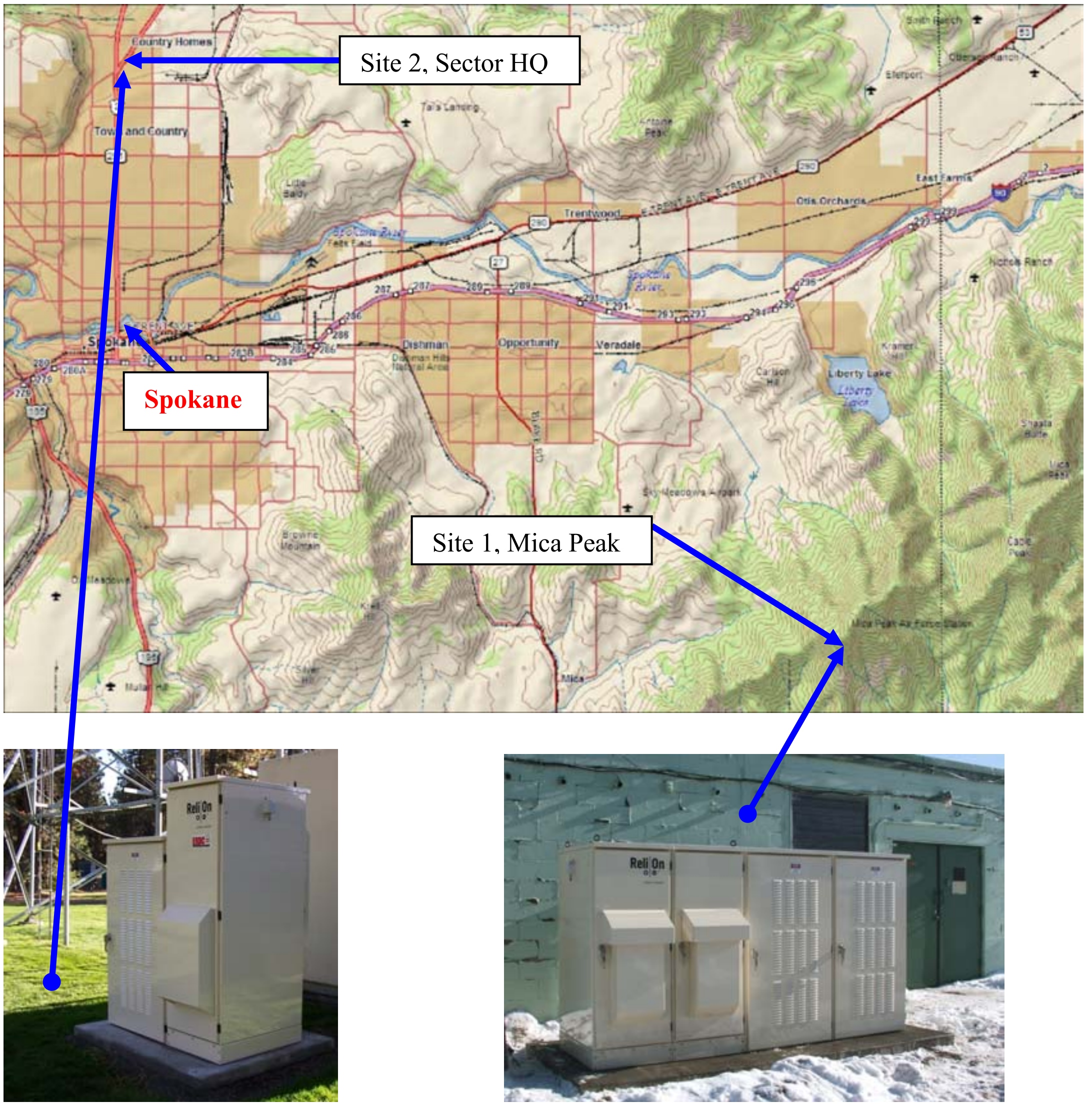



**Figure 1. CERL IV, Spokane, WA, System Locations**

Mica Peak site prior to installation

Sector HQ radio hut prior to installation

**Figure 2. CERL IV, Spokane, WA, Radio Equipment System Shelters**

8.0 Fuel Cell Installation

The ReliOn Fuel Cell Outdoor Enclosure is a self-contained, turn-key system that was delivered to the site ready to set on the concrete pad and wire in to AC and DC circuits and connected to a local analogue telephone line. The Scope of Work supplied by ReliOn to the general contractor for installation of the fuel cell systems including all power wiring and signal and control interconnections is given in Appendix 1. Installation drawings for the two fuel cell installation sites in Spokane are included in Appendix 2.

All fuel systems were started and tested between March 23, 2006 and May 31, 2006. The Mica Peak and U.S Customs and Border Protection Sector Headquarters sites were fully commissioned on June 1, 2006 and the 1-year test program was started on that date.

Mica Peak

HQ

**Figure 3. ReliOn Fuel Cell Installations supporting CERL IV located in Spokane, Washington at Mica Peak and U.S Customs and Border Protection Sector Headquarters.**

The daily test runs were scheduled to occur during normal business hours over periods of representative equipment loads. This also allowed ease of scheduling if host site personnel, ReliOn staff, and guests wish to observe the tests. The data was transferred from data capturing equipment in each enclosure to a remote server in each site shelter. The data was then downloaded to a server at ReliOn by remote dial-up after each system test run. The data logging computer also had an alarm notification utility that automatically dialed preprogrammed phone numbers that notified ReliOn personnel of any alarm condition. One analogue POTS telephone line is used for remote monitoring at each site. The tests at Mica Peak and U.S. Customs and Border Protection Headquarters are timed as shown in Table 1.

**Table 1. Spokane CERL IV Test Schedule**

| Site No. | Site Name | Local Test Time (Pacific) |
|---|---|---|
| 4-1 | Mica Peak | 10:00 AM |
| 4-2 | HQ | 9:00 AM |

The test run simulated a power outage everyday for a 60-minute time period in order to test the availability of the fuel cell system. A programmable logic controller (PLC) was installed with each system to simulate the grid outage by opening a relay to cut AC power to the site equipment. The PLC also monitored the run status of the fuel cells and would reconnect AC power to the site equipment if there were any type of operational failures that could have jeopardized the protected equipment. The fuel cells remain connected directly to the 24 Volt DC bus at each site. Once a day, AC power to the radio equipment was disconnected. At the same time, the fuel cells started and provided power to the loads for 1 hour. At the end of the test period, AC power was restored and the fuel cells shut down and returned to standby mode.

In addition to the daily test, the fuel cell systems were configured to monitor the commercial AC power grid as well as the status of the existing DC backup batteries at each site. Upon actual loss or failure of either power source, the fuel cells would start automatically to provide up to 96 kWh at Mica Peak (Site 4-1) and 48 kWh at U.S. Customs and Border Protection HQ (Site 4-2) of continuous run power to critical equipment at each site.

On-site maintenance is required when an alarm condition cannot be corrected remotely. Routine inspections and maintenance visits were scheduled once per quarter. The ReliOn I-1000® fuel cell is a system based on removable cartridges that house the PEM membranes. If a membrane fails, the system continues to operate and there is a visual indication, as well as remote indication (minor alarm) capability with the communications system. When it is convenient, the failed cartridge can be replaced, even while the system is running – hot-swappable. This task can be accomplished in less than 10 seconds, without the use of tools.

## 9.0 Electrical System

At each of the two sites, the fuel cell systems ran in a grid-independent mode with the only interconnection being an AC sensing circuit in the fuel cell enclosure. A block diagram showing the relationship between the fuel cell system and existing equipment is shown in Figure 4.

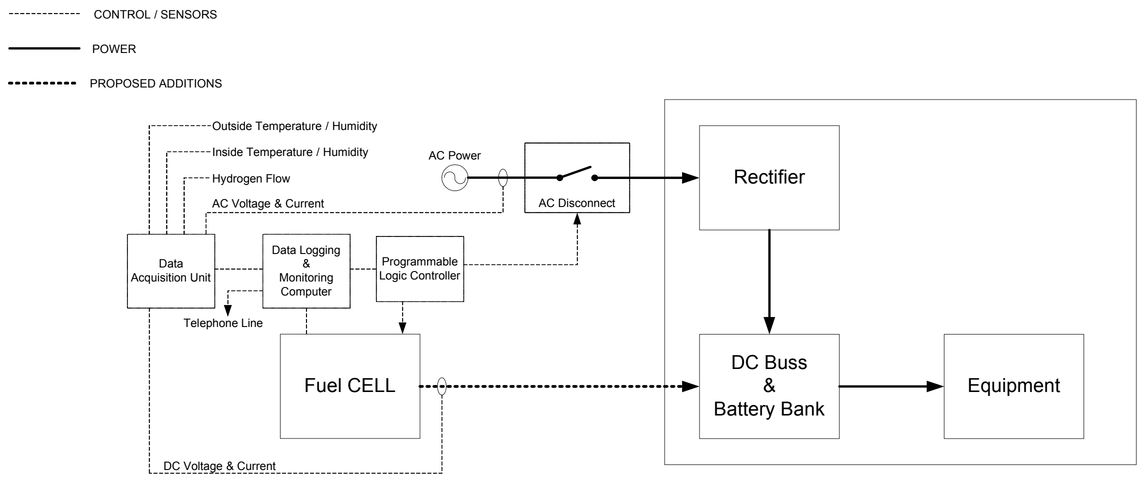



**Figure 4. Functional Block Diagram Showing Fuel Cell System Interconnection with Existing Equipment**

All systems were in a "remote" state and/or standby/ready mode to provide backup power for critical DC equipment when there was a loss of primary AC power or a rectifier failure. The following connections were established at each site:

- Electrical Requirements:
  - One 20 Amp circuit at each site for AC sense and the enclosure heater. The heater was and remains designed to keep the environment around the fuel cell above freezing to facilitate rapid startup. Once the fuel is running, it utilizes its own heat for operation. The heater remains as a part of the system design and was standard product feature supporting an I-1000® outdoor enclosure system.
  - AC disconnect relay at each site between AC power and rectifier. The disconnect relay remains but is no longer acting as relay.
  - DC connection at each site between fuel cell system and DC bus in customer's equipment cabinet. The DC connection remains.
  - At each site there was a PLC, data monitoring equipment, and data logging computer powered from the 24 VDC terminals inside the enclosure. This ensured that the data continue to be recorded during an extended AC outage. This equipment was removed when the site was transferred to a commercial status.
- Telephone Lines
  - One phone line required per site for data monitoring. The phone line remains but it no longer active.

- One computer server with dial-up capability at each site. This server has been removed as this was only necessary for the CERL test program.

- See Appendix 2 for site specific connections

## 10.0 Thermal Recovery System

Because ReliOn's PEM fuel cells operate at low temperatures, the system is not a cogeneration system. The system will be installed in an outdoor enclosure designed to maintain the internal temperature within the operating range of the I-1000®.

## 11.0 Data Acquisition System

Programmable Logic Controller (PLC) was used to start the fuel cell once a day for a test period of one hour. The PLC also energized a relay at the same time to disconnect AC power from the shelter rectifier.
A data acquisition system was also included in each enclosure to monitor and record the following:

- Inside temperature
- Inside Humidity
- Outside Temperature
- Outside Humidity
- AC Voltage at the site
- AC current at the shelter rectifier
- DC Voltage at the shelter DC bus
- DC current from the fuel cell
- Hydrogen fuel flow

All vital information from the I-1000® fuel cell is also monitored and recorded. The data-logging computer is connected to the data acquisition module and fuel cell via Ethernet. The data-logging computer is configured to dial a designated ReliOn personnel cell phone during any of the following alarm conditions:

- Loss of AC Voltage
- Low DC Voltage (Less than 25 VDC)
- Hydrogen Sensor Alarm
- Fuel Cell Major Alarm
- Hydrogen Bank Empty
- Enclosure Fan Alarm

The system was and remains configured to start automatically during a loss of the AC grid and in the event the facility DC bus voltage falls below a pre-determined limit (low voltage startup). The low voltage startup protects the radio equipment in case of a facility rectifier/charger failure or a fault in the battery string. The low voltage start threshold has been set at 25VDC for the radio sites at Mica Peak and Border Patrol HQ.

Monthly run data summaries from June 2006 to May of 2007 are included in Appendix 3.

## 12.0 Fuel Supply System

The fuel cell systems were fueled with standard industrial grade hydrogen gas. Compressed gas is the easiest and most commercially available source of industrial grade hydrogen. The outdoor enclosures at each of the two CERL IV sites included locked hydrogen storage and delivery systems which ensured that the compressed hydrogen cylinders are protected and accessible only to authorized personnel. Mica Peak (4-1) was and remains supported by a four compartment, 12 bottle configuration. Border Patrol Sector HQ (4-2) was and remains supported by a two compartment, six bottle configuration. An example sketch of the hydrogen compartments is shown in Figure 5.

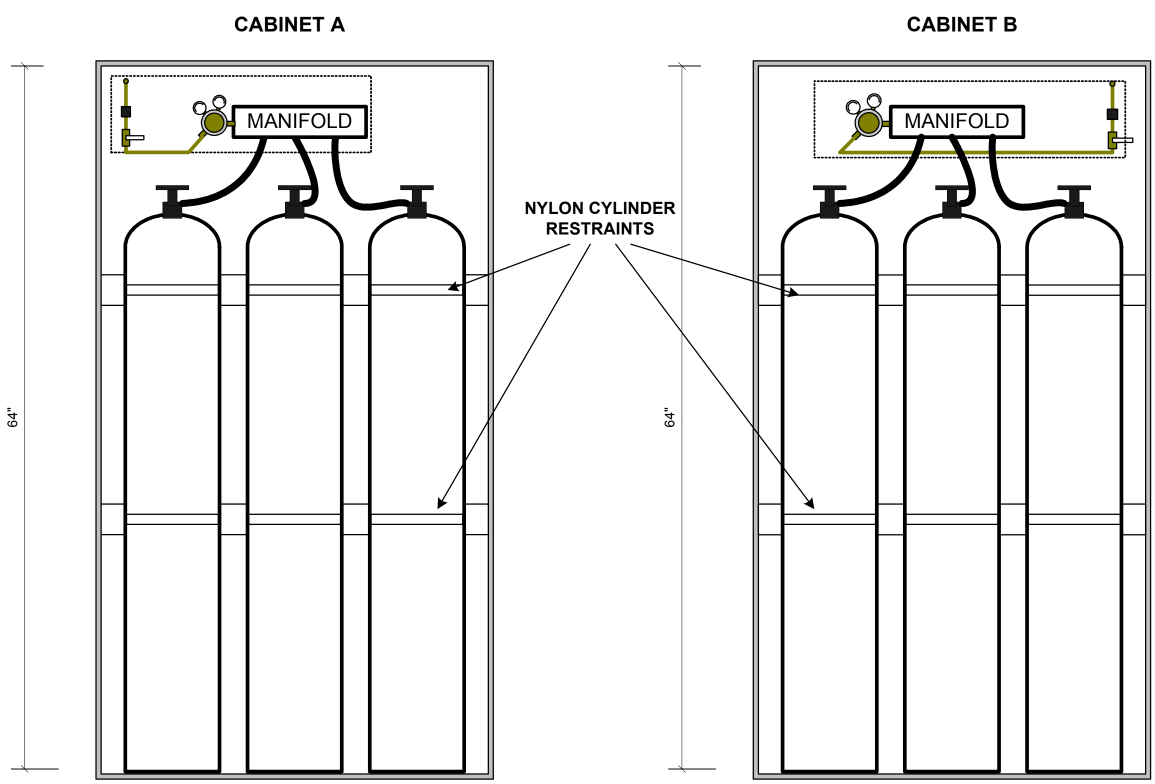



**Figure 5. Hydrogen Fuel Compartments**

The cylinders are typically size 300 (nominal 261 cu. ft or 8071 liter gas capacity at STP conditions), although size 200 can also be accommodated. Full cylinders were delivered with gas pressure at between 2000 and 2200 psig. Each of hydrogen storage compartments contained three cylinders directly connected into a high pressure manifold. The manifolds are equipped with pressure switches and a regulator to reduce the gas pressure for delivery to the fuel cell. The pressure switches were monitored by the data logging computer which sent an alarm to the ReliOn personnel when the gas pressure falls to a pre-determined level. This data logging equipment was removed at both sites during decommissioning and is not part of ReliOn product offerings. Hydrogen gas deliveries were made to each site by a local gas distributor at approximately four week intervals.

The optimal setting for the pressure regulators to the fuel cell is 40-50 psig. By adjusting the regulated pressures so that one bay is 5-10 psig higher than the other side, hydrogen will flow out of the higher pressure side only until those cylinders are exhausted. The system then drew hydrogen from the second manifold, allowing time to order and replace the depleted cylinders. The settings used during the test program remain at both sites.

The fuel supply system and refill logistics worked well throughout he duration of this project.

## 13.0 Installation Costs

Table 2 shows a breakdown of project costs thru May of 2007 for the ReliOn PEM fuel cell backup power demonstration project at both sites in Spokane, Washington. The total project proposed was $179,536.33.

## Table 2. Project Costs for Contract Number W9132T-04-R-BAA1 (Spokane, WA)

**CERL IV Project Management Plan**
**Total Project**

| **Task 1: Fuel Cell Power Plant**<br>**Direct Labor** | | Proposal Budget | Balance Remaining |
|---|---|---|---|
| Staff | Activity | | |
| Applications Engineer | Training | $760.00 | ($2,429.96) |
| **Travel** | | | |
| Local Mileage (1 Round Trip) | | $29.52 | ($41.04) |
| **Equipment** | | | |
| | | $62,971.00 | $2,471.00 |
| | | | |
| | | | |
| | | | |
| | | | |
| **Task 1 Subtotal Budget** | | **$63,760.52** | **$0.00** |

*All "Task" costs were estimated and placed under the title of "Proposed Budget". Some task costs were over estimate and some costs were under estimate. Project allocation was $179,536.33.

| **Task 2: Installation**<br>**Direct Labor** | | Proposal Budget | Balance Remaining |
|---|---|---|---|
| Staff | Activity | | |
| Engineering | Test Equipment Procurement, Enclosure Build, Software Development | $7,600.00 | $0.00 |
| Applications Engineer | Site Work | $6,840.00 | ($190.00) |
| Principal Investigator | Site Work | $3,000.00 | ($500.00) |
| | | | |
| **Travel** | | | |
| Local Mileage (4 Round Trips) | | $118.08 | ($54.00) |
| **General/Electrical Contractor** | | | |
| Contractor Installation (Assume $75 per hour + equip & materials) | | $20,000.00 | ($2,077.46) |
| **Materials & Expenses** | | | |
| Telephone Jack Installation | | $300.00 | $15.20 |
| | | | |
| **Task 2 Subtotal Budget** | | **$37,858.08** | **($2,806.26)** |

*All "Task" costs were estimated and placed under the title of "Proposed Budget". Some task costs were over estimate and some costs were under estimate. Project allocation was $179,536.33.

| **Task 3: Performance Monitoring**<br>**Direct Labor** | | Proposal Budget | Balance Remaining |
|---|---|---|---|
| Staff | Activity | | |
| Applications Engineer | Monitoring & Data Management | $1,200.00 | ($485.00) |
| Principal Investigator | Monitoring & Data Management | $10,000.00 | ($4,055.00) |
| | | | |
| **Materials & Expenses** | | | |
| Monthly Telephone Service | | $2,160.00 | ($880.20) |
| | | | |
| **Task 3 Subtotal Budget** | | **$13,360.00** | **($5,420.20)** |

*All "Task" costs were estimated and placed under the title of "Proposed Budget". Some task costs were over estimate and some costs were under estimate. Project allocation was $179,536.33.

**Table 2 (Continued).**
**Project Costs for Contract Number W9132T-04-R-BAA1 (Spokane, WA)**

| **Task 4: Maintenance**<br><br>**Direct Labor** | | Proposal Budget | Balance Remaining |
|---|---|---|---|
| Staff | Activity | | |
| Applications Engineer | Remote & Site Maintenance | $5,700.00 | ($2,197.00) |
| Principal Investigator | Remote & Site Maintenance | $3,000.00 | ($425.00) |
| | | | $0.00 |
| **Travel** | | | |
| Local Mileage (10 Round Trips) | | $295.20 | ($43.06) |
| **Materials & Expenses** | | | |
| Spare Parts | | $3,800.00 | $3,800.00 |
| | | | |
| **Task 4 Subtotal Budget** | | **$12,795.20** | **$1,134.94** |

*All "Task" costs were estimated and placed under the title of "Proposed Budget". Some task costs were over estimate and some costs were under estimate. Project allocation was $179,536.33.

| **Task 5: Project Management & Reporting**<br><br>**Direct Labor** | | Proposal Budget | Balance Remaining |
|---|---|---|---|
| Staff | Activity | | |
| Project Manager | Management, Reporting, Meetings | $4,500.00 | ($643.00) |
| Principal Investigator | Management, Reporting, Meetings | $10,000.00 | ($925.00) |
| | | | |
| **Travel** | | | |
| Local Mileage (2 Round Trips to Sector HQ for Kickoff & Acceptance Test Meetings) | | $46.08 | $0.00 |
| **Task 5 Subtotal Budget** | | **$14,546.08** | **($1,568.00)** |

*All "Task" costs were estimated and placed under the title of "Proposed Budget". Some task costs were over estimate and some costs were under estimate. Project allocation was $179,536.33.

| **Task 6: Decommissioning/Site Restoration**<br><br>**Direct Labor** | | Proposal Budget | Balance Remaining |
|---|---|---|---|
| Staff | Activity | | |
| Applications Engineer | Site Work | $4,459.00 | ($5,725.04) |
| Principal Investigator | Site Work | $1,466.00 | $1,466.00 |
| | | | $0.00 |
| **Travel** | | | |
| Local Mileage (2 Round Trips) | | $59.04 | $59.04 |
| **General/Electrical Contractor** | | | |
| Contractor Installation (Assume $75 per hour + equip & materials) | | $4,200.00 | $4,200.00 |
| **Task 6 Subtotal Budget** | | **$10,184.04** | **$0.00** |

*All "Task" costs were estimated and placed under the title of "Proposed Budget". Some task costs were over estimate and some costs were under estimate. Project allocation was $179,536.33.

**Table 2 (Continued).**
**Project Costs for Contract Number W9132T-04-R-BAA1 (Spokane, WA)**

| Task 7: Other Costs<br><br>Equipment & Expenses | Proposal Budget | Balance Remaining |
|---|---|---|
| | $27,032.41 | $8,659.52 |
| | | |
| | | |
| | | |
| | | |
| | | |
| **Task 7 Subtotal Budget** | **$27,032.41** | **$8,659.52** |
| *All "Task" costs were estimated and placed under the title of "Proposed Budget". Some task costs were over estimate and some costs were under estimate. Project allocation was $179,536.33. | | |
| **Project Total** | **$179,536.33** | **$0.00** |

## 14.0 Milestones/Improvements

At both test sites through the end of the 1-year test program, there were a total of 728 starts and 731.82 hours of run time. Both fuel cell solutions exceeded the minimum reliability objective of 90% with rating of 100% and 99.2 percent. In addition to the daily test runs, the ReliOn Fuel Cell systems at these sites maintained critical equipment functionality over two primary power outages totaling 4 hours, 46 minutes and 13 seconds during the demonstration period.

## 15.0 Decommissioning/Removal/Site Restoration

Pre installation pictures can be seen in section 7 of this document. Post decommissioning pictures can be seen in Figure 6. Upon completion of the successful test program, the host requested that the fuel cell systems remain for continued primary back-up power support of their radio equipment. Both sites, Site 4-1 – U.S. Border Patrol Repeater Station, Mica Peak, Washington, and Site 4-2 – U.S. Border Patrol Sector Head Quarters, Spokane, Washington, have been successfully decommissioned as CERL test sites and are now classified as “commercial” site installations. All test and monitoring equipment used for data gathering and monitoring purposed during the test program have been removed and fuel supply logistics have been handed over to U.S Customs and Border Protection Sector Headquarters, Spokane, Washington.

Site 4-1, Mica Peak after site was decommissioned. This site is now a standard commercial installation.

Site 4-2, Boarder Patrol HQ after site was decommissioned. This site is now a standard commercial installation.

**Figure 6. ReliOn Fuel Cell Installations as standard commercial installations located in Spokane, Washington at Mica Peak and U.S Customs and Border Protection Sector Headquarters.**

## 16.0 Conclusions/Summary

Through the end of the 1-year test program, there were a total of 366 starts and 365.02 hours of run time at Site 1, Mica Peak. At Site 2, Border Patrol Sector Head Quarters, there were a total of 362 starts and 366.8 hours of run time.

In addition to the daily test runs, the ReliOn Fuel Cell systems at these sites maintained critical equipment functionality over two primary power outages totaling 4 hours, 46 minutes and 13 seconds during the demonstration period. At Site 1, Mica Peak, there was one primary power outage period of 1 minute, 13 seconds. At Site 2, Border Patrol Sector Head Quarters, the duration of the primary power outage was 4 hours, 45 minutes.

The cumulative reliability for the entire 1-year demonstration program at Site 1, Mica Peak was 100% and cumulative availability was 100 percent. At Site 2, Border Patrol Sector Head Quarters both fuel cells were inadvertently disabled by an operator during a system check in January of 2007. This human error resulted in the both fuel cell systems not being available to perform the daily test for three days. Because of the operator error, the cumulative reliability for the demonstration program at Site 2, Border Patrol Sector Head Quarters was 99.2% and cumulative availability was 99.2% for the entire 1-year demonstration period. Had the operator properly toggled the system control switch to a "remote" status, cumulative reliability and cumulative availability would have been 100% at Site 2, Border Patrol Sector Head Quarters.

Consistent with the reporting criteria established under the CERL program, all system outages, regardless of origin, have been reported in the monthly data summaries and accounted for in the reliability and availability calculations for the system.

Appendix

1) ReliOn Fuel Cell System Site Preparation Contractor Scope of Work
2) Fuel Cell Installation Drawings
3) Monthly Performance Data
4) Commissioning Procedures for the I-1000® Fuel Cell & Outdoor Enclosure System

Appendix 1

ReliOn Fuel Cell System Site Preparation Contractor Scope of Work

Site 1 – Mica Peak
Site 2 – Sector HQ

ReliOn, Inc.
15913 E. Euclid Ave.
Spokane, Washington 99216
Telephone 509-228-6500
Facsimile 509-228-6510
www.relion-inc.com

October 6, 2005

# Site Preparation and Fuel Cell Installation Scope of Work

## DHS Customs & Border Protection
## Mica Peak Repeater Station
## Mica Peak, Washington

**All material required must be provided by the contractor unless stated**

## Material Provided By ReliOn

1. 24 VDC, 120 Amp ReliOn Fuel Cell Outdoor Enclosure system with four hydrogen fuel wings. The enclosure system will be configured for transport on two separate 5' x 6' pallets. Pallet No. 1 with the fuel cell compartments weighs 770 lb. Pallet No. 2 with the hydrogen fuel wings weighs 668 lb. The fuel cell compartments and the hydrogen wings are also equipped with lifting eyes for picking and setting. The enclosure system pallets shall be transported from the ReliOn factory to the installation site (approximately 26 miles) by the contractor.
2. Valere 80 Amp rectifier.
3. Exeltech 5000 W 24 VDC inverter.
4. 23" equipment rack.
5. 4 pole AC disconnect relay and 6" x 6" x 6" pull box.
6. AC current sensor.
7. All special test instrumentation, computer, Ethernet hub, and modem equipment.
8. A ReliOn Application Engineer will be available during equipment installation to provide guidance and assistance in equipment location and installation.

## Material And Services Provided By Contractor

1. All necessary permits for electrical work as required.
2. Gravel and concrete work as described in Paragraph 2 below.
3. Truck transport of the Fuel Cell Outdoor Enclosure from the ReliOn factory to the installation site.
4. Fork lift at the installation site capable of carrying a minimum 1000 lb. load and transporting across a gravel parking area. The fork lift will be required to lift and locate the pallets containing the fuel cell enclosure components from the truck to the concrete pad.
5. Three (3) 120 VAC 20 Amp breakers to be installed in existing Radio Equipment Building AC distribution panel.
6. 120 VAC 20 Amp duplex receptacle, utility box, and plug as required to connect the new Valere rectifier to the new 4 pole AC disconnect relay (AC Circuit 2).

7. 120 VAC 20 Amp quadruplex receptacle, 20 Amp breaker, and utility box as required to supply power from the new Exceltech inverter.
8. Two (2) 24 VDC 100 Amp disconnects and utility box as required to isolate the fuel cell and new Exeltech inverter from the existing DC battery bank.
9. Fasteners to secure the outdoor enclosure to the concrete pad as described in paragraph 2 below.
10. All wiring, terminals, conduit, clamps, supports, and other materials necessary to complete work as described in this Scope of Work.

## Site Preparation

1. **Sites:** The following work shall be completed at the radio equipment building located on the Mica Peak property of the Department of Homeland Security, Customs & Border Protection.

   The Fuel Cell Installation Drawing Package shows system installation at the project site.

2. **Fuel Cell Pad Preparation:** At the location shown in Detail 2 of the Fuel Cell Installation Drawing Package level and fill an approximate 6' x 13' area with a minimum 6-inch deep compacted #57 minus or ¾ minus gravel bed. The foundation shall be capable of supporting a minimum load of 200 $lb/ft^2$. Install forms and rebar for a concrete pad as shown in Detail 3 of the Fuel Cell Installation Drawing Package. The concrete pad shall be capable of supporting a minimum load of 550 $lb/ft^2$. ReliOn recommends a concrete pad thickness of 6 inches. Detail 3 shows the locations of the concrete anchors and the 4" x 10" conduit cutout. Full -sized layout templates for the fuel cell enclosure will be supplied by ReliOn. These templates also serve as gaskets to be installed between the concrete pad and the enclosure. To secure the enclosure to the concrete pad, 1/2" - 13 UNC J-bolts may be imbedded into the concrete or the holes can be drilled later and concrete anchors installed. Fasteners shall be passivated stainless steel or plated per ASTM-A153.

3. **Electrical Boxes & Panels:**

   a. Install three (3) 120 VAC 20 Amp breakers in the existing Radio Equipment Building AC distribution panel located on the north interior wall of the building.
   b. On the west interior wall of the Radio Equipment Building, mount a 6" x 6" x 6" pull box. Install the Allen Bradley 4 pole AC disconnect relay and the AC current transducer in the pull box.
   c. On the east interior wall of the Radio Equipment Building, install two utility boxes to contain two DC disconnects, each rated for 100 Amp, 24 VDC. One DC disconnect will be used to isolate the fuel cell system DC output from the existing battery string. The second DC disconnect will be used to isolate the 24 VDC input to the new Exeltech inverter from the existing battery string.
   d. On the east interior wall of the Radio Equipment Building, install a utility box to contain a 120 VAC 20 Amp breaker and a quadruplex receptacle. This circuit

will be powered by the Exceltech inverter and will be separate from the commercial AC grid.

e. On the new 23" equipment rack, install a utility box to contain a 120 VAC 20 Amp duplex receptacle. This receptacle will be powered by one of the new 20 Amp breakers (AC Circuit 2) in the existing AC distribution panel and will be switched by the AC disconnect relay contained in the pull box described in 3b above.

4. **Conduit Installation**:

Install three (3) runs of rigid conduits at a depth of 24 inches from the conduit opening at the fuel cell pad to the Radio Equipment Building as depicted in Detail 2 in the Fuel Cell Installation Drawing Package. Conduit 1 should be at least 2" in order to contain 5 runs of shielded CAT 5 network cable and 5 pairs of 18 AWG signal wire. Conduit 2 should be sufficiently sized to pull 2 runs of 4/0 AWG DC power cable. Conduit 3 should be sufficiently sized to pull 3 runs of 12 AWG AC circuit wire (AC Circuit 1). Use 90 degree sweeps to bring the conduits out of the ground to a level of approximately 8'-9" above grade at the west exterior wall of the Radio Equipment Building as depicted in the Fuel Cell Installation Drawing Package. Use existing abandoned wall penetrations located on 2' centers, approximately 8'-9" above ground level. Seal the penetrations as required for weather tight service. At the fuel cell pad location use 90-degree sweeps to bring the conduits out of the ground to a level of 8 inches above the finished upper surface of the concrete pad at the locations depicted in Details 2 and 3 in the Fuel Cell Installation Drawing Package.

4. **Inside Conduit Installation:** Inside the Radio Equipment Building, install EMT conduit from the DC power conduit penetration (conduit number 2) to the fuel cell system DC disconnect. Install EMT conduit from the AC power conduit penetration (conduit number 3) to the pull box containing the AC disconnect relay (located on the west interior wall). Install EMT conduit from the pull box to the AC distribution panel in the Radio Equipment Building. Install EMT conduit to contain AC Circuit 2 from the pull box to the new utility box containing the duplex receptacle described in 3e above. This conduit will also contain AC Circuit 3 to the Exceltech inverter location on the new 23" equipment rack. Install a conduit run as required from the Exceltech inverter location to the new utility box containing the 20 Amp breaker and quadruplex receptacle as described in 3d above.

5. **Ground Cable Installation:** Install 2/0 AWG bare copper ground cable from the fuel cell pad location as depicted in the Fuel Cell Installation Drawing Package. Leave 10 feet of cable coiled at the fuel cell pad location. Connect the ground cable to the existing stranded wire ground halo inside the Radio Equipment Building using a mechanical lug, or other approved connection compatible with local code and practice for above grade grounding. Use one of the existing abandoned wall penetrations located on 2' centers, approximately 8'-9" above ground level on the west exterior wall of the building.

6. **Cable/Wire Installation:** Install the following wires and cables to connect the fuel cell system to the Radio Equipment Building.

   a. **DC Power Cables:** Install two (2) runs of 4/0 AWG Type THHN copper cable in conduit number 2 from the new DC disconnect box in the Radio Equipment Building to the fuel cell pad. Leave 10-feet of cable coiled at each end.

   b. **AC Power Wires**: Pull 3 circuits of 12 AWG copper wires in the EMT conduit from the pull box to the AC distribution panel in the Radio Equipment Building. Pull AC Circuit 1 in conduit number 3 from the pull box to the fuel cell pad. Pull AC Circuit 2 in EMT conduit from the pull box to the new utility box containing the duplex receptacle described in 3e above. Pull AC Circuit 3 in EMT conduit from the pull box to the Exceltech inverter location on the new 23" equipment rack. Leave 10 feet of wire coiled at each end.

   c. **Control/Alarm Wires**: Pull five (5) runs of shielded CAT 5 network cable in conduit number 1 from the fuel cell pad to the Radio Equipment Building. Install five runs of black 18 AWG Type THHN copper wires and five red 18 AWG Type THHN copper wires in conduit number 1 from the fuel cell pad to the Radio Equipment Building. Number wire runs on each end to aid identification during termination (instrument connections will be made by a ReliOn engineer). Leave 10 feet of wire coiled at the fuel cell pad end. Leave 30 feet of CAT 5 cable and THHN copper wire coiled at the penetration of conduit number 1 inside the Radio Equipment Building. A ReliOn applications engineer will connect the control and alarm wiring to the computer and Ethernet hub (located in the new 23-inch equipment rack). The THHN copper signal wiring will be connected (by the ReliOn engineer) to the AC disconnect relay in the new pull box.

## Enclosure Installation

1) **Enclosure Placement**: The contractor must supply a fork lift capable of lifting and transporting a 1000 lb. load across a gravel parking area. A ReliOn engineer will be available to assist in placement and assembly of the outdoor enclosure on the concrete pad. To secure the enclosure to the concrete pad, 1/2" - 13 UNC J-bolts may be imbedded into the concrete or the holes can be drilled later and concrete anchors installed. Fasteners shall be passivated stainless steel or plated per ASTM-A153.

2) **Electrical Connections (See details in the Fuel Cell Installation Drawing Package)**: Make the following connections between the fuel cell enclosure and Radio Equipment Building.

   a) **AC Power Wires**: Refer to Detail 8 of the Fuel Cell Installation Drawing Package. AC Circuit 1 supplies the fuel cell enclosure through the AC disconnect relay. Connect the hot side conductor of this circuit through NC poles 31 and 32 on the relay. Connect the AC power wires from this circuit to the AC junction box in the fuel cell enclosure. AC Circuit 2 supplies the new utility box containing the duplex receptacle described in 3e above through the AC disconnect relay and current sensor in line as shown in Detail 8 of the Fuel Cell Installation Drawing Package. Connect the hot side conductor of this circuit through NC poles 21 and 22 on the relay. Feed the hot side conductor line through the AC current transducer in the pull box. A ReliOn applications engineer will connect the control wires to the AC disconnect relay and current sensor. AC Circuit 3 supplies the Exceltech inverter as described in 6b above. AC Circuit 3 is not controlled by the AC disconnect relay.

a) **Ground Cable:** Connect the ground cable to the fuel cell enclosure ground bar.

b) **Control / Alarm Wires:** A ReliOn applications engineer will connect all control wires inside the shelter and inside the fuel cell enclosure.

c) **DC Power Wires:** Noting the DC system polarity, connect the DC power wires at the fuel cell enclosure terminal block first. Connect the DC power wires to the new fuel cell system DC disconnect.

ReliOn, Inc.
15913 E. Euclid Ave.
Spokane, Washington 99216
Telephone 509-228-6500
Facsimile 509-228-6510
www.relion-inc.com

July 27, 2005

# Site Preparation and Fuel Cell Installation Scope of Work

## DHS Customs & Border Protection
## Spokane Sector Headquarters
## Spokane, Washington

**All material required must be provided by the contractor unless stated**

## Material Provided By ReliOn

1. 24 VDC, 80 Amp ReliOn Fuel Cell Outdoor Enclosure system with two hydrogen fuel wings. (Note: The complete Fuel Cell Enclosure system weighs 1,630 lb. It is equipped with lifting eyes for picking and setting.)
2. Composite concrete pad to support fuel cell enclosure. (Note: The composite concrete pad is about 4" thick and weighs 700 lb. It is packaged on a 60" x 72" pallet for shipping and handling.)
3. Exeltech 5000 W 24 VDC inverter and support shelf.
4. 4 pole AC disconnect relay and 6" x 6" x 6" pull box.
5. AC current sensor.
6. All special test instrumentation, computer, Ethernet hub, and modem equipment.
7. A ReliOn Application Engineer will be available during equipment installation to provide guidance and assistance in equipment location and installation.

## Material Provided By Contractor

1. All necessary permits for electrical work as required.
2. No. 57 minus or ¾" minus gravel for structural fill as described in Paragraph 6.
3. Utility box, 120 VAC 20 Amp breaker and 20 Amp duplex receptacle.
4. 120 VAC 20 Amp breaker to be installed in existing radio equipment shelter AC distribution panel.
5. Two (2) 24 VDC 100 Amp disconnects and utility box as required to isolate the fuel cell and new Exeltech inverter from the existing DC battery bank.
6. 120 VAC 20 Amp receptacle and plug as required to connect the existing rectifier to the new 4 pole AC disconnect relay.
7. All wiring, terminals, conduit, clamps, supports, and other materials necessary to complete work as described in this Scope of Work.

## Site Preparation

1. **Sites:** The following work will be completed at the radio equipment shelter located behind the Spokane Sector Headquarters of the Department of Homeland Security, Customs & Border Protection at the following address:

   Customs & Border Protection
   Spokane Sector Headquarters
   10710 N. Newport Highway
   Spokane, WA 99218-1642

   The Fuel Cell Installation Drawing Package details system installation at the project site.

2. **Electrical Boxes & Panels:**

   a. Install a utility box to contain two DC disconnects, each rated for 100 Amp, 24 VDC adjacent to the existing DC breaker panel above the battery tray located in the radio equipment shelter. One DC disconnect will be used to isolate the fuel cell system DC output from the existing battery string. The second DC disconnect will be used to isolate the 24 VDC input to the new Exeltech inverter from the existing battery string.
   b. Mount a 6" x 6" x 6" pull box on the north interior wall of the radio equipment shelter. Install the Allen Bradley 4 pole AC disconnect relay and the AC current transducer in the pull box. Install an outlet receptacle in the pull box. This new receptacle will be used to supply commercial grid AC power to the existing rectifier in the equipment rack.
   c. Install a utility box located approximately 4 ft. above the battery tray located in the radio equipment shelter. Install a 120 VAC, 20 Amp breaker and 20 Amp duplex receptacle in the utility box. Provide a length of armored flex conductor to feed the 20 Amp breaker from the new Exeltech 5000 W inverter (supplied by ReliOn). The inverter will be located on a shelf (supplied and installed by ReliOn) above the battery tray.
   d. Install a duplex receptacle and a utility box on or near the ceiling of the radio equipment shelter and near the existing east-west cable tray. Install a run of EMT conduit (surface mounted) to connect the new 20 Amp breaker (from 'c' above) to the new receptacle. This receptacle will be powered by the Exeltech inverter and will be separate from the commercial AC grid.

3. **Conduit Installation**:

   Install three (3) runs of minimum schedule 40 PVC conduits at a depth of 24 inches from the radio equipment shelter to the fuel cell pad location as depicted in Detail 2 in the Fuel Cell Installation Drawing Package. Conduit 1 should be at least 2" in order to contain 5 runs of shielded CAT 5 network cable and 5 pairs of 18 AWG signal wire. Conduit 2 should be sufficiently sized to pull 2 runs of 1/0 AWG DC power cable.  Conduit 3 should be sufficiently sized to pull 3 runs of 12 AWG AC circuit wire.  Use 90 degree sweeps to bring the conduits out of the ground to a level of 4-feet above grade at the location depicted in the Fuel Cell Installation Drawing Package.  Cut three holes in the side of the shelter for the three conduits.  Place conduit sleeves inside the three shelter penetration holes.  Install conduit pull elbows on each of the conduit sleeves on the outside of the shelter penetration holes.  Seal the penetrations with caulk.  Terminate the conduits coming out of the ground at the bottom of the pull elbows.  At the fuel cell pad location use 90-degree radius sweeps to bring the conduits out of the ground to a level of 12-inches above the finished grade at the locations depicted in Details 2 and 3 in the Fuel Cell Installation Drawing Package.

4. **Inside Conduit Installation:**  Inside the radio equipment shelter, install EMT conduit from the DC power conduit penetration (conduit number 2) to the DC breaker panel for the DC power cables from the fuel cell enclosure.  Install EMT conduit from the AC power conduit penetration (conduit number 3) to the pull box containing the AC disconnect relay.  Install EMT conduit from the pull box to the AC distribution panel in the radio equipment shelter.  Install EMT conduit runs as required to interconnect 120 VAC shelter rectifier circuit through the AC disconnect relay in the pull box.

5. **Ground Cable Installation:**  Install 1/0 AWG bare copper ground cable from the radio equipment shelter skid at the northeast corner of the building to the fuel cell pad location as depicted in the Fuel Cell Installation Drawing Package.  Leave 10 feet of cable coiled at the fuel cell pad location.  Connect the ground cable to the shelter skid using an exothermic weld (e.g. cad-weld or equivalent), or other approved connection compatible with local code and practice for above grade grounding.

6. **Fuel Cell Pad Preparation:**  At the location shown in Detail 2 fuel cell installation drawing package cut and remove a 54-inch wide x 78-inch long area of sod.  Level and fill area with a minimum 6-inch deep compacted #57 minus or ¾ minus gravel bed.  The finished surface of the gravel shall be even with, or slightly above crowns of surrounding grass.

7. **Composite Concrete Pad Installation:  I**nstall the composite concrete pad on the compacted gravel pad as shown in the Fuel Cell Installation Drawing Package.  The composite concrete pad weighs approximately 700 lbs.

8. **Cable/Wire Installation:**  Install the following wires and cables to connect the fuel cell system to the radio equipment shelter.

    a. **DC Power Cables:**  Install two (2) runs of 1/0 AWG Type THHN copper cable in conduit number 2 from the new DC disconnect box in the radio equipment shelter to the fuel cell pad.  Leave 10-feet of cable coiled at each end.

    b. **AC Power Wires**:  Install three 12 AWG Type THHN copper wires (Black, White & Green) in conduit number 3 from the pull box containing the AC disconnect relay to the fuel cell pad. Install three 12 AWG Type THHN copper wires (Black, White & Green) in the EMT conduit from the pull box to the AC distribution panel in the radio equipment shelter. Leave 10 feet of wire coiled at each end.

c. **Control/Alarm Wires**: Pull five (5) runs of shielded CAT 5 network cable in conduit number 1 from the fuel cell pad to the radio equipment shelter. Install five runs of black 18 AWG Type THHN copper wires and five red 18 AWG Type THHN copper wires in conduit number 1 from the fuel cell pad to the radio equipment shelter. Number wire runs on each end to aid identification during termination. Leave 10 feet of wire coiled at the fuel cell pad end. Leave a minimum of 30 feet of CAT 5 cable and THHN copper wire coiled at the penetration of conduit number 1 inside the radio equipment shelter. A ReliOn applications engineer will connect the control and alarm wiring to the computer and Ethernet hub (to be mounted in the existing 19-inch equipment rack). The THHN copper signal wiring will be connected (by the ReliOn engineer) to the AC disconnect relay in the new pull box.

## Enclosure Installation

1) **Enclosure Placement**: Place the enclosure on the composite concrete pad. Bolt the enclosure to the composite pad using the 12 embedded mounting nuts. Use 1/2” x 1” stainless steel bolts.

2) **Electrical Connections (See details in the Fuel Cell Installation Drawing Package)**: Make the following connections between the fuel cell enclosure and radio equipment shelter.

   a) **AC Power Wires**: Connect the AC power wires between a new 20 Amp circuit breaker in the shelter circuit breaker box and the new AC disconnect relay. Connect the hot side conductor through one of the available NC poles on the relay. Connect the AC power wires from the disconnect relay in the shelter to the AC disconnect in the fuel cell enclosure.

   b) **AC Disconnect Relay:** Disconnect the AC power wire from the shelter rectifier and place the AC disconnect relay and current sensor in line as shown in Detail 5 of the fuel cell installation drawing package. Connect the hot side conductor through the second available NC pole on the relay. Feed the hot side conductor line through the AC current transducer in the pull box. A ReliOn applications engineer will connect the control wires to the AC disconnect relay and current sensor.

   c) **Control / Alarm Wires:** A ReliOn applications engineer will connect all control wires inside the shelter and inside the fuel cell enclosure.

d) **DC Power Wires:** Connect the DC power wires at the fuel cell enclosure terminal block first. Connect the DC power wires to the new 100 Amp DC breaker in the existing DC breaker panel above the battery tray located in the radio equipment shelter.

e) **Ground Cable:** Connect the ground cable to the fuel cell enclosure ground bar.

Appendix 2

Fuel Cell Installation Drawings

Site 1 – Mica Peak
Site 2 – Sector HQ

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# CBP Mica Peak Repeater Station (CERL 4)
# Test Equipment Electrical & Instrumentation Drawings

## Index of Details




ReliOn
15913 East Euclid Avenue
Spokane, Washington 99216

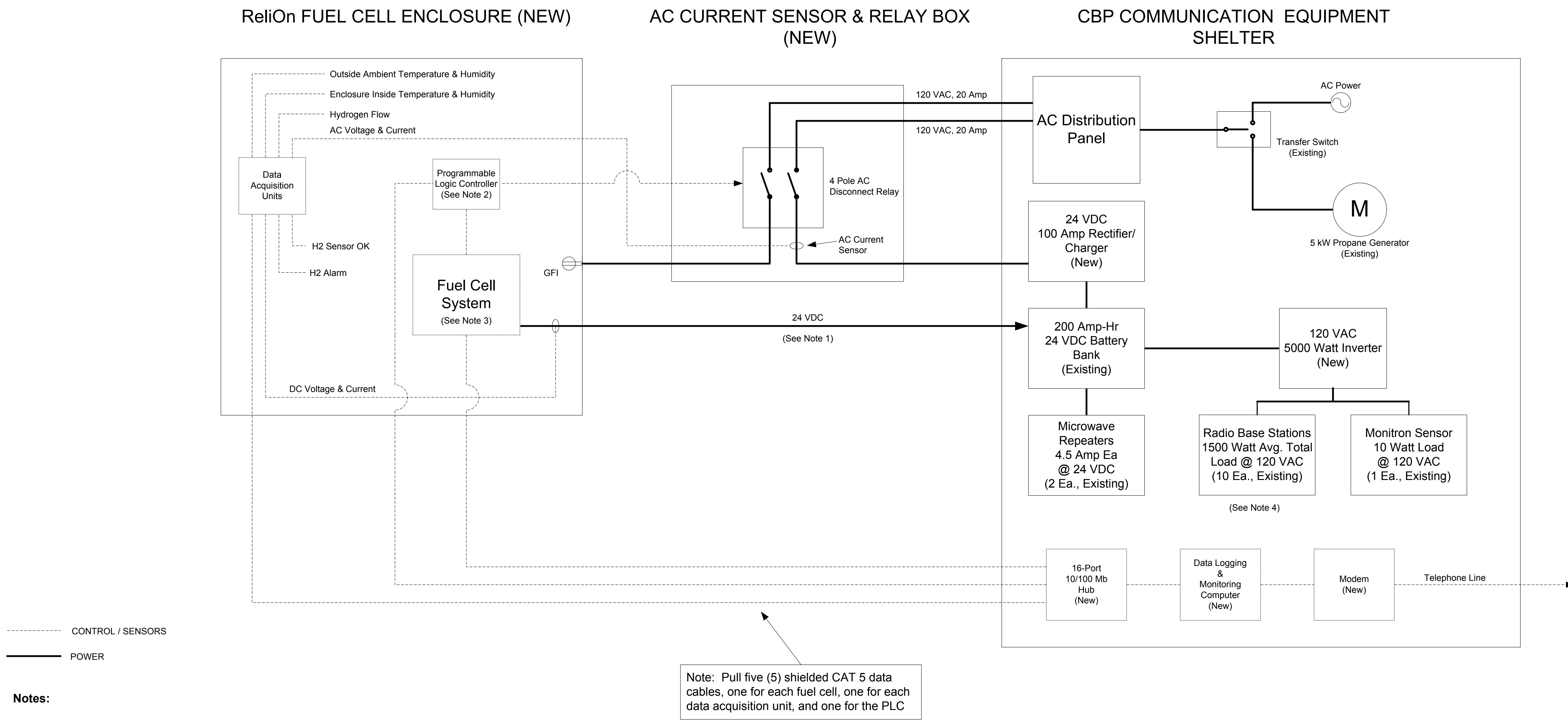



| | |
|---|---|
| PROJECT CERL IV | TITLE Electrical & Instrumentation |
| CUSTOMER Army Corp of Engineers, ERDC/CERL | FILE CBP Mica Pk E&I Rev C.vsd |
| SITE DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington | SHEET 1 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 1 FUNCTIONAL BLOCK DIAGRAM

NO SCALE




**Notes:**

**1.** The Fuel Cell System will be connected in parallel with the DC bus and Battery Bank. Connect fuel cell output to battery bank through DC breaker.

**2.** A Programmable Logic Controller will activate a relay to simulate loss of AC power and start the Fuel Cell System. The Fuel Cell will power the site for 1 hour. The Programmable Logic Controller will then deactivate the relay to return AC power.

**3.** The system will also be configured to start and power the site during an actual AC power outage or in the event that a rectifier fails.

**4.** Site contains 10 GE and Motorola radios. Total power draw of all radios while on transmit status (keyed mic) is about 5860 Watt. Assume overall average transmit duty at 20%.

ReliOn
15913 East Euclid Avenue
Spokane, Washington 99216

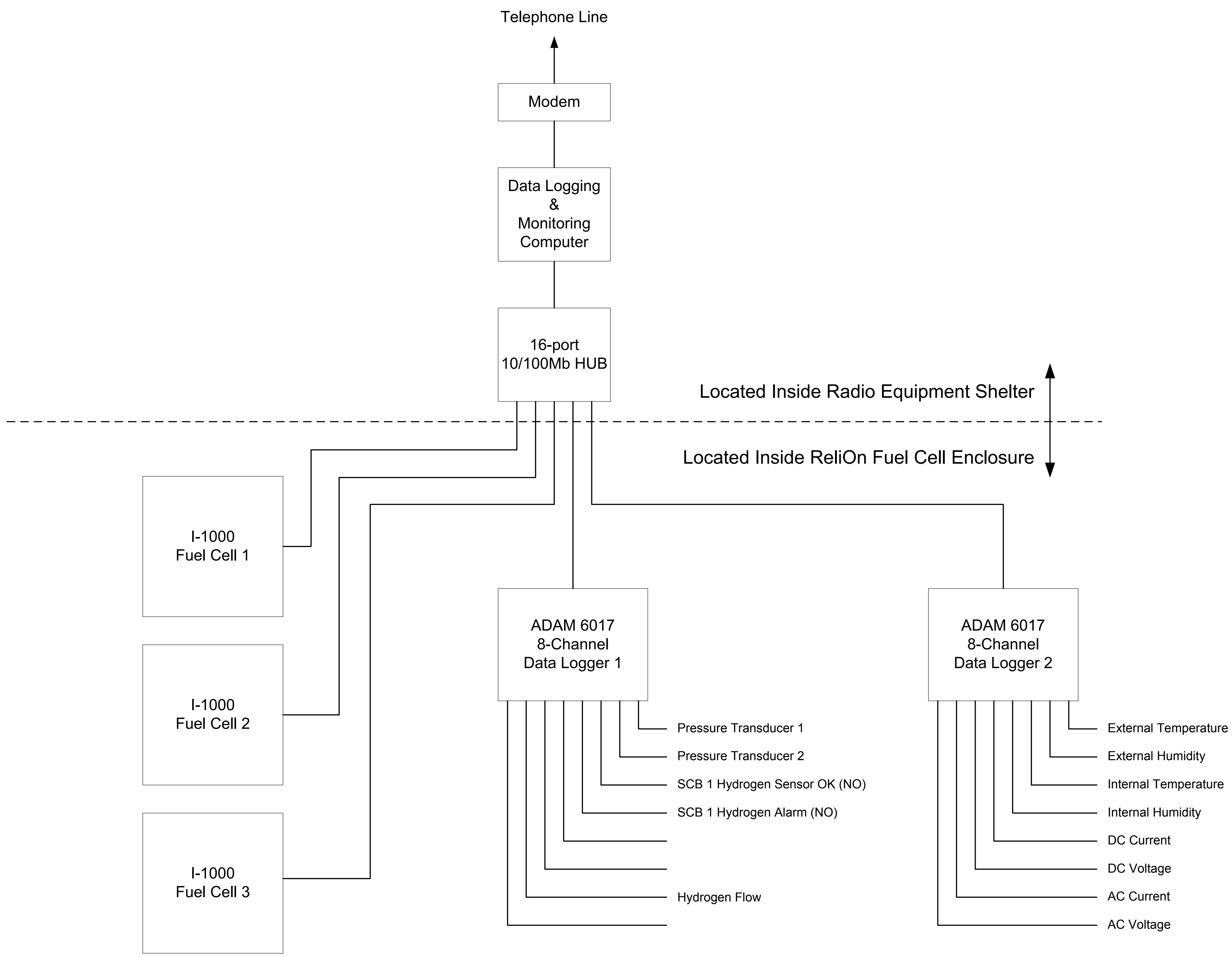


| | |
|---|---|
| PROJECT | CERL IV |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL |
| SITE | DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington |
| TITLE | Electrical & Instrumentation |
| FILE | CBP Mica Pk E&I Rev C.vsd |
| SHEET | 2 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 2 DATA LOGGING BLOCK DIAGRAM

NO SCALE





ReliOn
15913 East Euclid Avenue
Spokane, Washington 99216

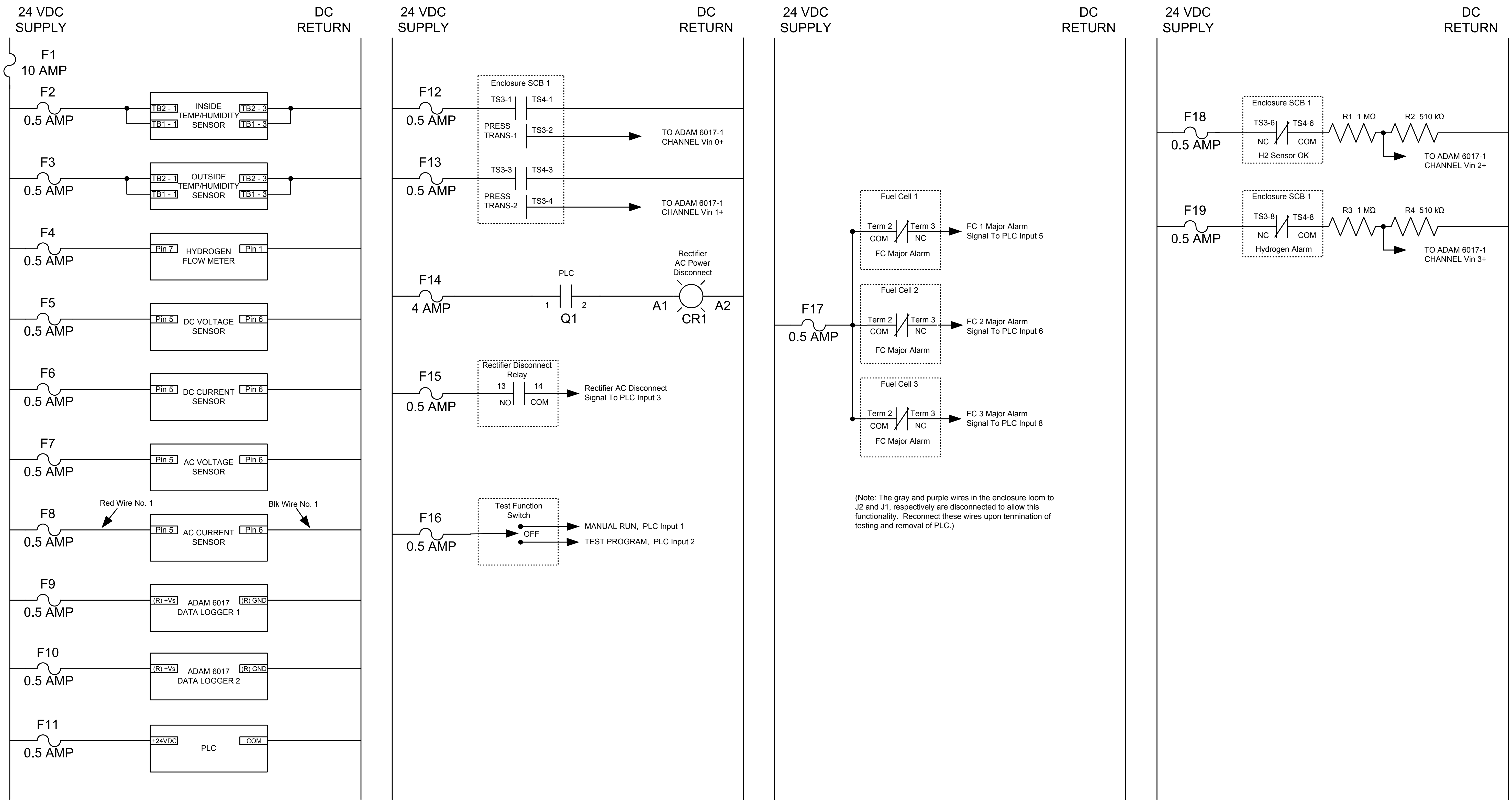



| | |
|---|---|
| PROJECT | CERL IV |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL |
| SITE | DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington |
| TITLE | Electrical & Instrumentation |
| FILE | CBP Mica Pk E&I Rev C.vsd |
| SHEET | 3 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 3 TEST INSTRUMENTATION DC SCHEMATIC

NO SCALE




**Notes:**

1. System is designed for +24 VDC.

Reli On
15913 East Euclid Avenue
Spokane, Washington 99216



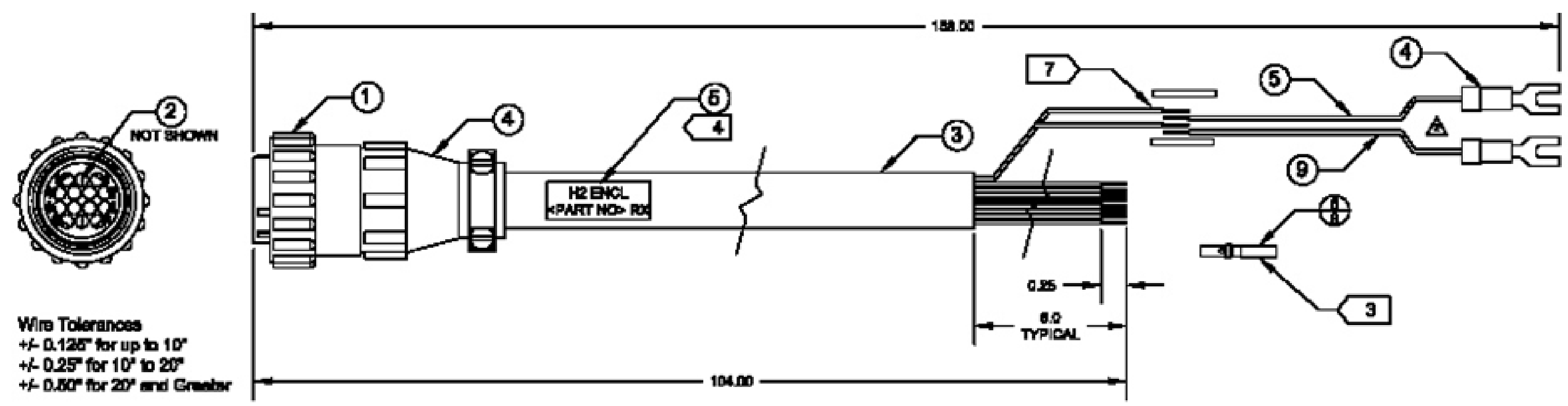
| | |
|---|---|
| PROJECT | CERL IV |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL |
| SITE | DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington |
| TITLE | Electrical & Instrumentation |
| FILE | CBP Mica Pk E&I Rev C.vsd |
| SHEET | 4 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 4 MANIFOLD PRESSURE TRANSDUCER CONNECTIONS

NO SCALE

CABLE, H2 ENCL, W/DIN CONN, J69 (DWG NO. 263-105218)




| WIRE COLOR & CONTACT LEGEND | | | |
|---|---|---|---|
| PIN | COLOR | SIGNAL | TERMINATION |
| 1 | WHITE | PS1 COMMON | SOCKET |
| 2 | RED | PS1 NO | SOCKET |
| 3 | BLACK | PS1 GROUND | SOCKET |
| 4 | BLUE | SOLENOID (-) | N/A |
| 5 | ORANGE | SOLENOID (+) | N/A |
| 6 | GREEN | SOLENOID GROUND | N/A |
| 7 | BROWN | PS1 NC | SOCKET |
| 8 | - | NO CONNECTION | - |
| 9 | PURPLE | DOOR ALARM (NO) | RED WIRE W/FORK TERMINAL |
| 10 | YELLOW | DOOR ALARM (COM) | BLK WIRE W/FORK TERMINAL |
| 11 | RED/GRN | PS2 GROUND | SOCKET |
| 12 | RED/BLK | PS2 COMMON | SOCKET |
| 13 | TAN | PS2 NO | SOCKET |
| 14 | GRAY | PS2 NC | SOCKET |

Notes:

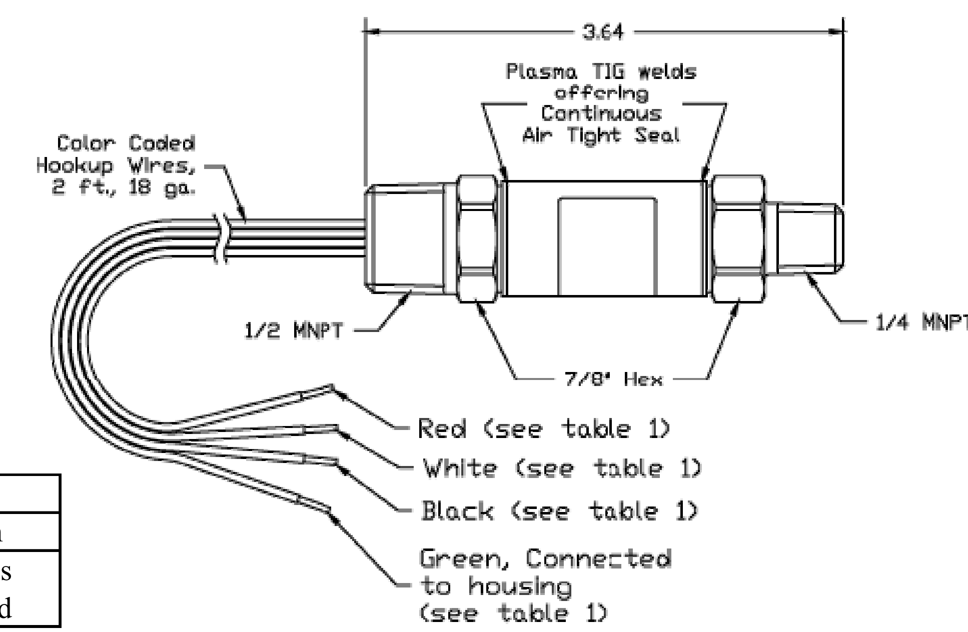
1. Connect Red (+V Supply) wire from pressure transducer to Pin 2 (Red Wire) of H2 Enclosure Cable.

2. Connect Black (-V Supply) wire from pressure transducer to Pin 1 (White Wire) of H2 Enclosure Cable.

3. Connect White (1-5 V Output) wire from pressure transducer to Pin 7 (Brown Wire) of H2 Enclosure Cable.

4. Connect Green (Housing Ground) wire from pressure transducer to Pin 3 (Black Wire) of H2 Enclosure Cable.

American Sensor Technology AST4600 Pressure Transducer




| Table 1--Pressure Transducer Wiring Connections | | | | |
|---|---|---|---|---|
| Output | Red | Black | White | Green |
| 1-5 V | + 10-28 VDC | DC Return | 1-5 V Output Signal | Chassis Ground |

ReliOn

15913 East Euclid Avenue
Spokane, Washington 99216

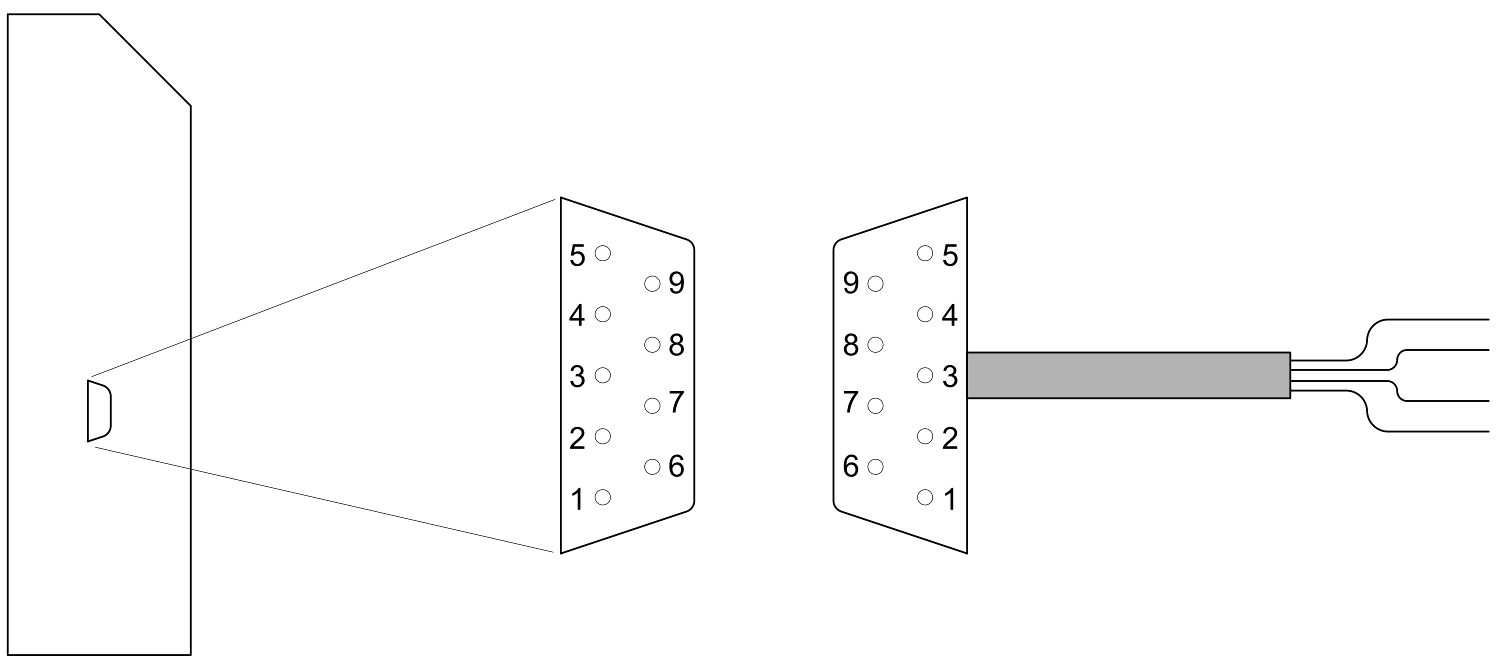


| | |
|---|---|
| PROJECT | CERL IV |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL |
| SITE | DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington |
| TITLE | Electrical & Instrumentation |
| FILE | CBP Mica Pk E&I Rev C.vsd |
| SHEET | 5 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 5 HYDROGEN FLOW METER CONNECTIONS

NO SCALE



Pin 1 - Power Supply DC Return - Black

Pin 4 - Flow Meter 0-5 VDC Output - White (ADAM 6017-1 Channel Vin 4+)

Pin 7 - Power Supply + 24 VDC - Red (Fuse F4)

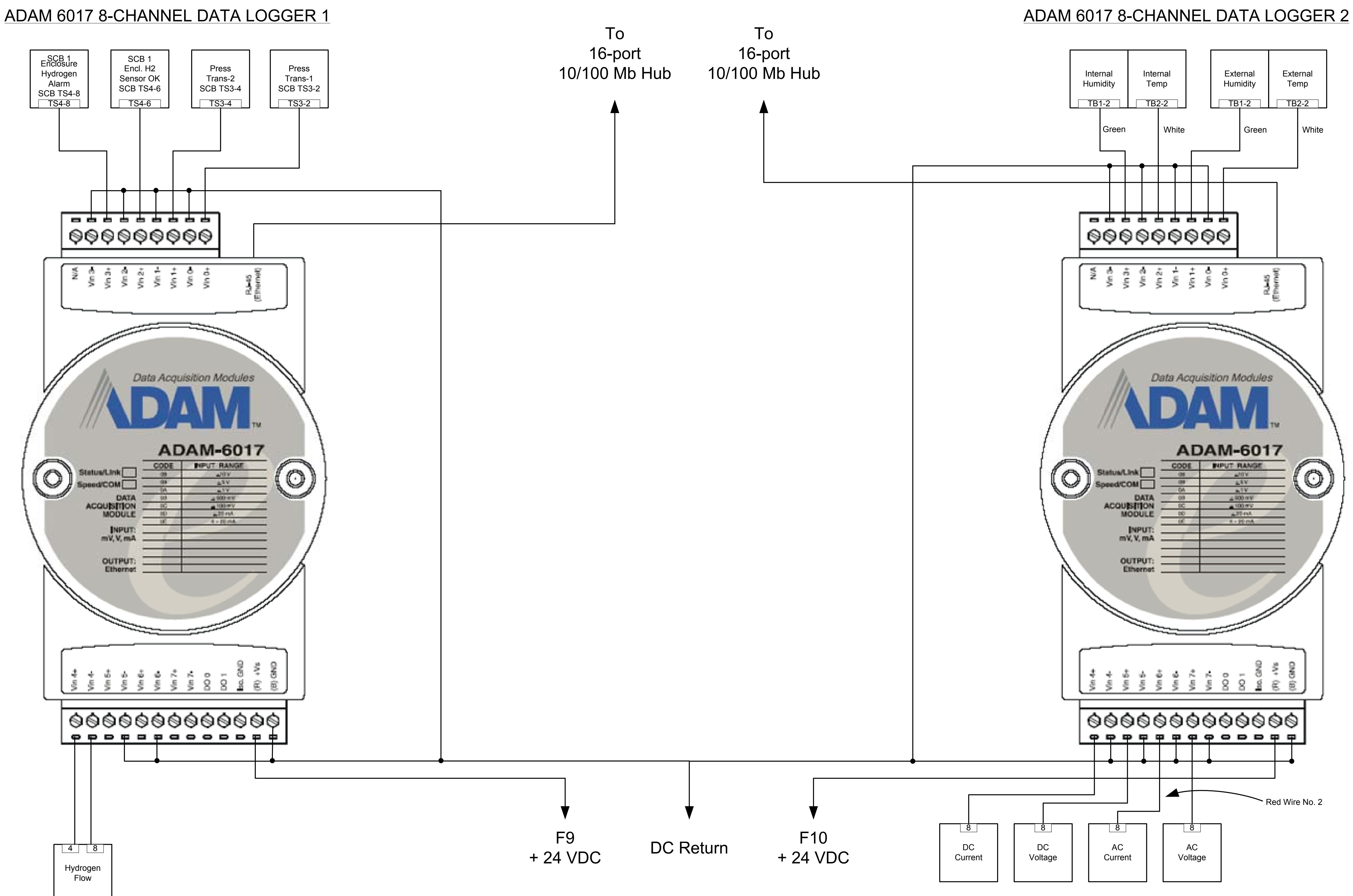
Pin 8 - Flow Meter DC Common Output - Green (ADAM 6017-1 Channel Vin 4-)

| | | | |
|---|---|---|---|
| ReliOn<br>15913 East Euclid Avenue<br>Spokane, Washington 99216 | NOTICE OF PROPRIETARY INFORMATION | PROJECT CERL IV | TITLE Electrical & Instrumentation |
| | The information contained in this document is confidential and considered proprietary to Relion, Inc. Any use, transfer, or duplication of the information contained herein is strictly forbidden without the express written consent of Relion, Inc. | CUSTOMER Army Corp of Engineers, ERDC/CERL | FILE CBP Mica Pk E&I Rev C.vsd |
| | | SITE DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington | SHEET 6 of 12 |

# DETAIL 6  FUEL CELL SYSTEM DATA ACQUISITION WIRING DIAGRAM

NO SCALE

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

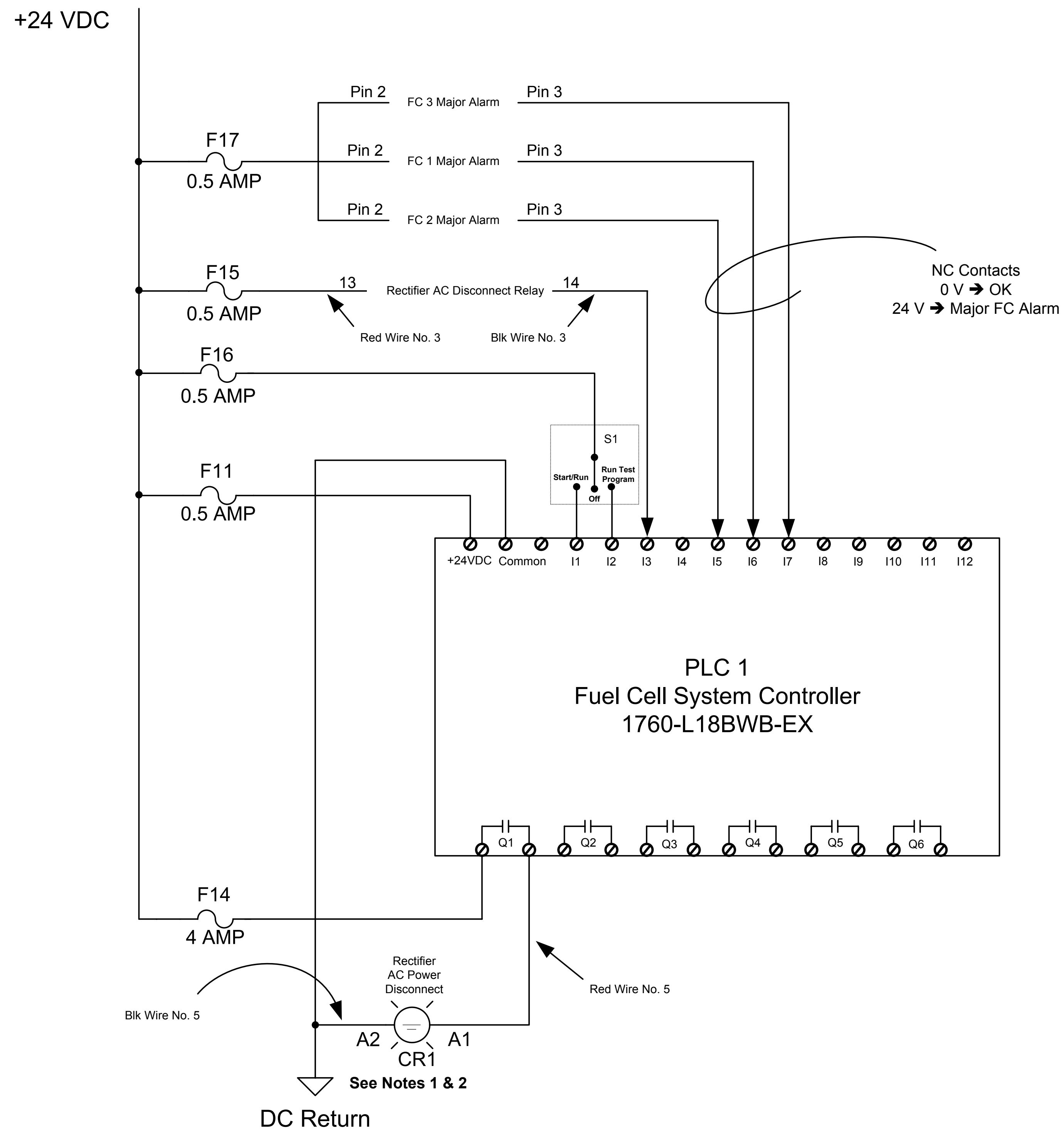



| | | | |
|---|---|---|---|
| ReliOn<br>15913 East Euclid Avenue<br>Spokane, Washington 99216 | NOTICE OF PROPRIETARY INFORMATION<br>The information contained in this document is confidential and considered proprietary to Relion, Inc. Any use, transfer, or duplication of the information contained herein is strictly forbidden without the express written consent of Relion, Inc. | PROJECT: CERL IV<br>CUSTOMER: Army Corp of Engineers, ERDC/CERL<br>SITE: DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington | TITLE: Electrical & Instrumentation<br>FILE: CBP Mica Pk E&I Rev C.vsd<br>SHEET: 7 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 7 PLC CONNECTIONS

NO SCALE




**Notes:**

**1.** PLC is programmed to simulate an AC power loss to the Shelter Rectifier by energizing normally closed contacts of CR1 and disconnecting the AC power to the Rectifier.

**2.** AC disconnect relay CR1 Is located in the shelter inside the 6x6x6 pull box.

ReliOn
15913 East Euclid Avenue
Spokane, Washington 99216

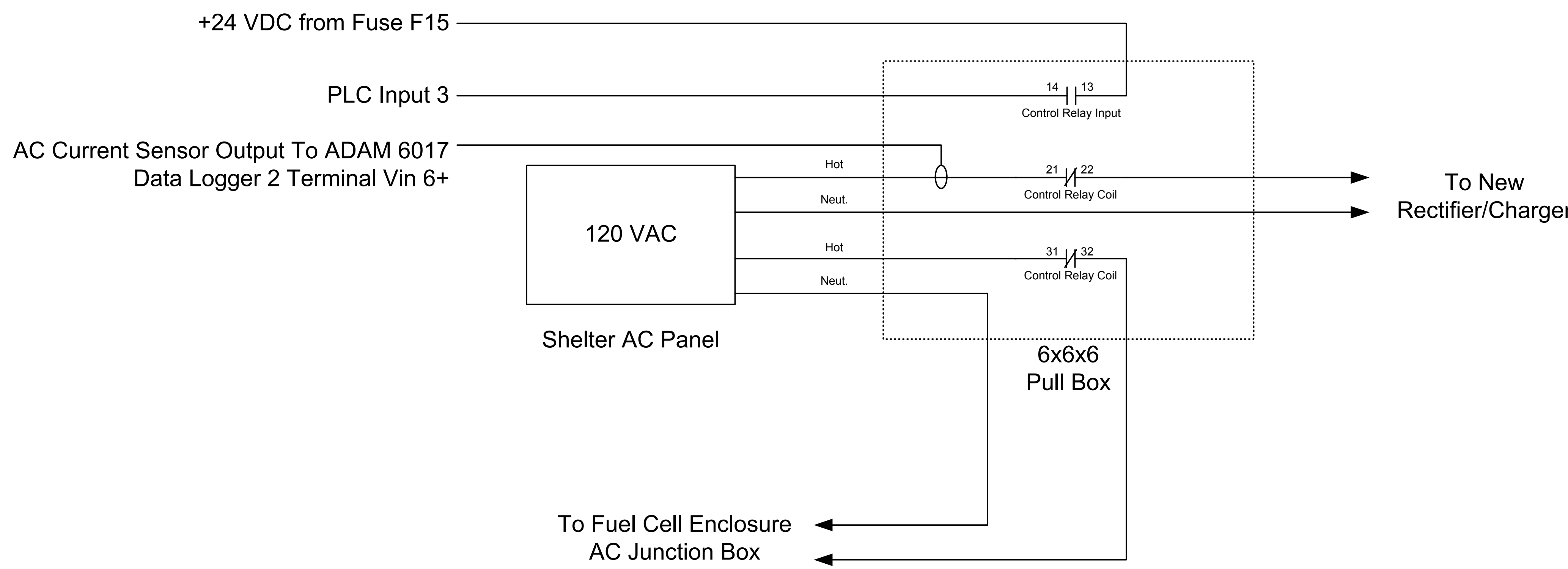


| | |
|---|---|
| PROJECT | CERL IV |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL |
| SITE | DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington |
| TITLE | Electrical & Instrumentation |
| FILE | CBP Mica Pk E&I Rev C.vsd |
| SHEET | 8 of 12 |

# DETAIL 8 RECTIFIER AC DISCONNECT RELAY & AC CURRENT SENSOR CONNECTIONS

NO SCALE

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |




ReliOn

15913 East Euclid Avenue
Spokane, Washington 99216

NOTICE OF PROPRIETARY INFORMATION



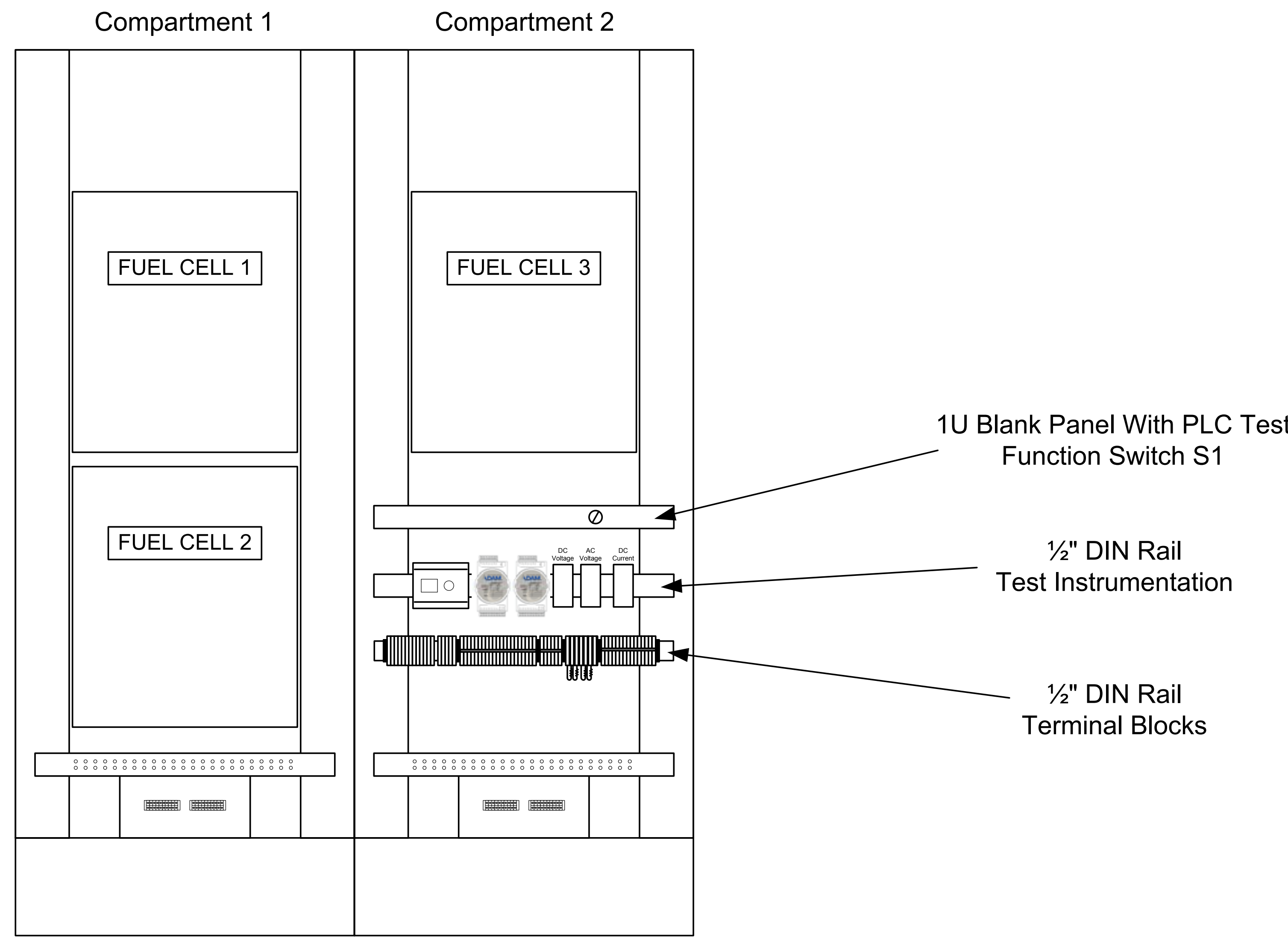
| | |
|---|---|
| PROJECT | CERL IV |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL |
| SITE | DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington |
| TITLE | Electrical & Instrumentation |
| FILE | CBP Mica Pk E&I Rev C.vsd |
| SHEET | 9 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 9 TEST INSTRUMENT DIN RAIL PLACEMENT

SCALE: 1" = 1' - 0"

Fuel Cell Compartments
Rear View

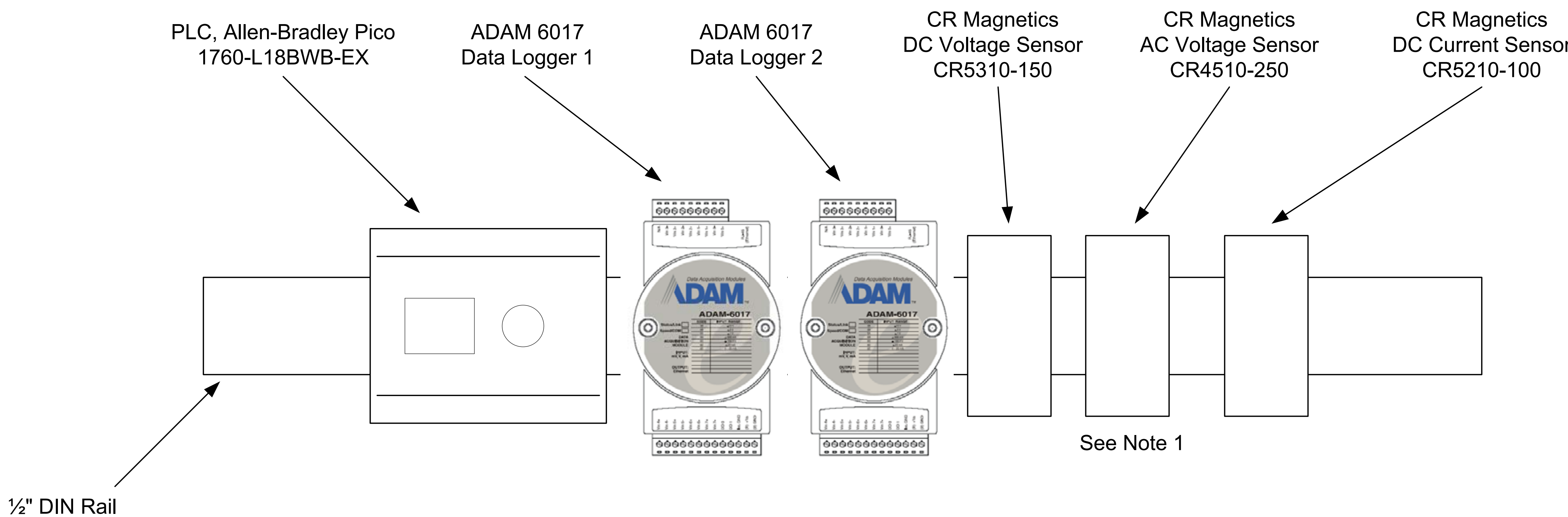



| | | | |
|---|---|---|---|
| ReliOn<br>15913 East Euclid Avenue<br>Spokane, Washington 99216 | NOTICE OF PROPRIETARY INFORMATION<br>The information contained in this document is confidential and considered proprietary to Relion, Inc. Any use, transfer, or duplication of the information contained herein is strictly forbidden without the express written consent of Relion, Inc. | PROJECT CERL IV | TITLE Electrical & Instrumentation |
| | | CUSTOMER Army Corp of Engineers, ERDC/CERL | FILE CBP Mica Pk E&I Rev C.vsd |
| | | SITE DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington | SHEET 10 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
| --- | --- | --- | --- | --- |
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 10 TEST INSTRUMENTATION & CONTROL DIN RAIL LAYOUT

NO SCALE




Notes:

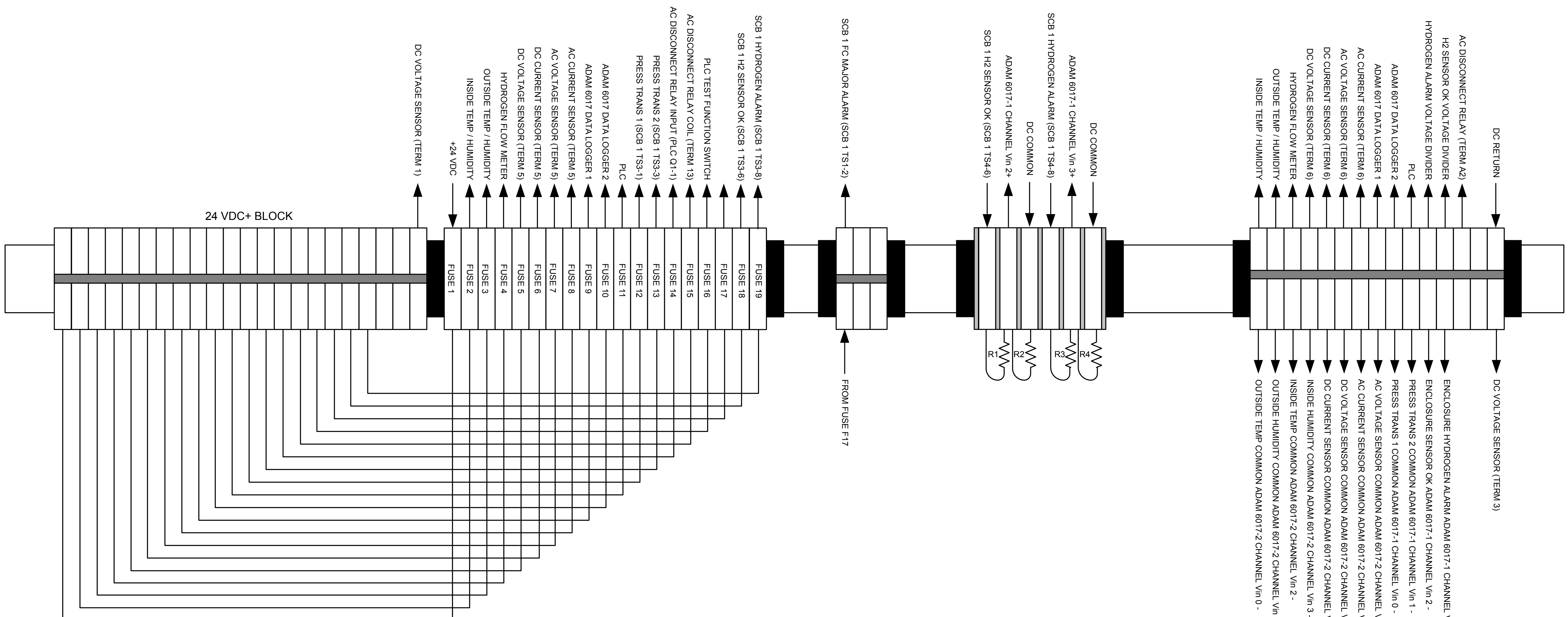
1. Connect Terminals 1 and 3 to AC Hot and Neutral, Respectively in Enclosure AC Junction Box

| | | | |
| --- | --- | --- | --- |
| Reli On<br>15913 East Euclid Avenue<br>Spokane, Washington 99216 | NOTICE OF PROPRIETARY INFORMATION<br>The information contained in this document is confidential and considered proprietary to Relion, Inc. Any use, transfer, or duplication of the information contained herein is strictly forbidden without the express written consent of Relion, Inc. | PROJECT CERL IV<br>CUSTOMER Army Corp of Engineers, ERDC/CERL<br>SITE DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington | TITLE Electrical & Instrumentation<br>FILE CBP Mica Pk E&I Rev C.vsd<br>SHEET 11 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 11 TEST INSTRUMENTATION TERMINAL BLOCK
# DIN RAIL CONNECTION LAYOUT

NO SCALE





ReliOn
15913 East Euclid Avenue
Spokane, Washington 99216




| | |
|---|---|
| PROJECT | CERL IV |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL |
| SITE | DHS Customs & Border Protection, Mica Peak Repeater Station, Spokane, Washington |
| TITLE | Electrical & Instrumentation |
| FILE | CBP Mica Pk E&I Rev C.vsd |
| SHEET | 12 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# CBP Spokane Sector Headquarters (CERL 4)
# Test Equipment Electrical & Instrumentation Drawings

## Index of Details




ReliOn

15913 East Euclid Avenue
Spokane, Washington 99216

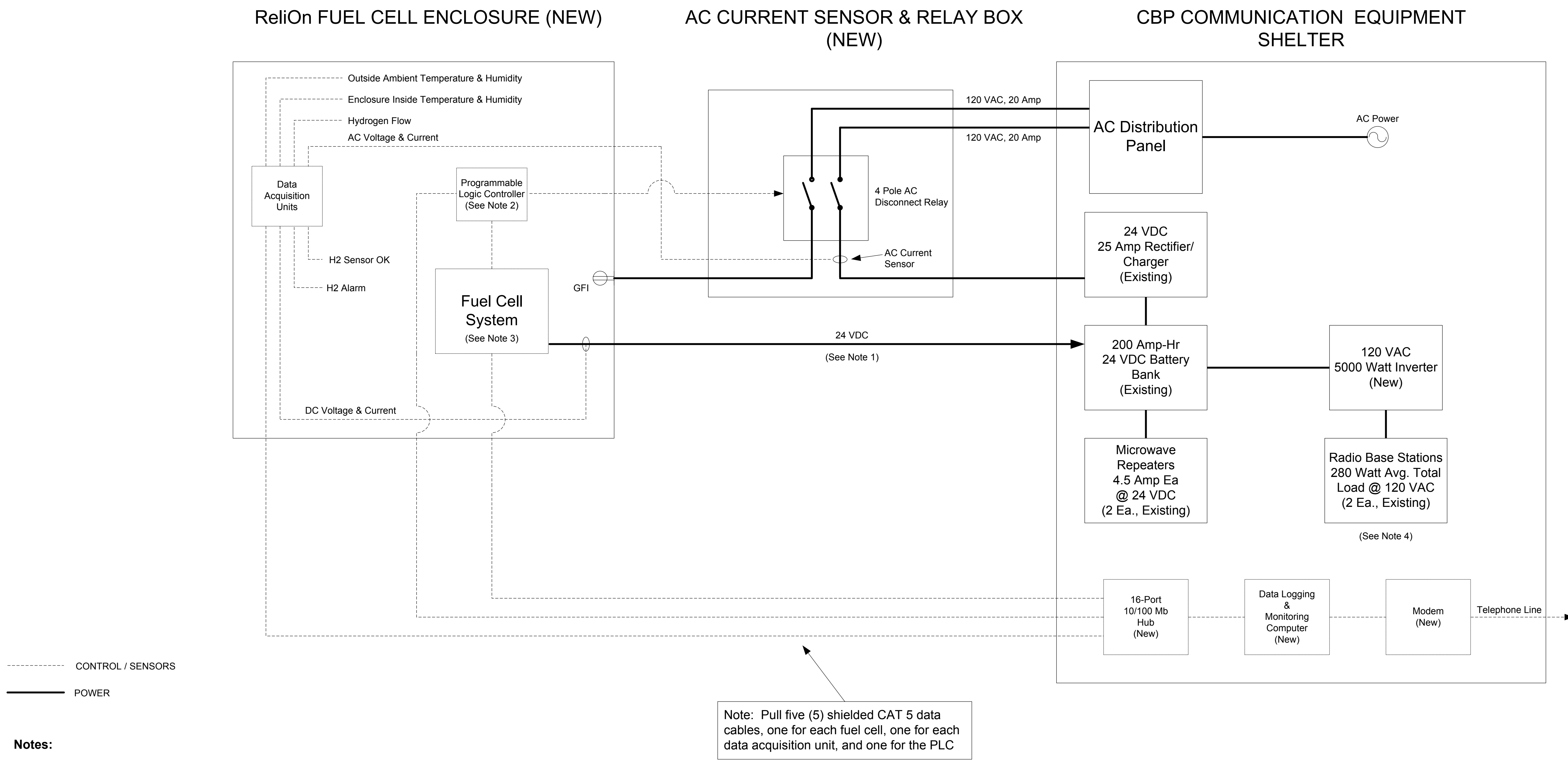



| | | | |
|---|---|---|---|
| PROJECT | CERL IV | TITLE | Electrical & Instrumentation |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL | FILE | CBP Spkn HQ E&I Rev C.vsd |
| SITE | DHS Customs & Border Protection, Spokane Sector Headquarters, Washington | SHEET | 1 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 1 FUNCTIONAL BLOCK DIAGRAM

NO SCALE




**Notes:**

**1.** The Fuel Cell System will be connected in parallel with the DC bus and Battery Bank. Connect fuel cell output to battery bank through DC breaker.

**2.** A Programmable Logic Controller will activate a relay to simulate loss of AC power and start the Fuel Cell System. The Fuel Cell will power the site for 1 hour. The Programmable Logic Controller will then deactivate the relay to return AC power.

**3.** The system will also be configured to start and power the site during an actual AC power outage or in the event that a rectifier fails.

**4.** Site previously incorporated 2 GE radios. As of June 8, 2005 one radio has been removed.


ReliOn
15913 East Euclid Avenue
Spokane, Washington 99216

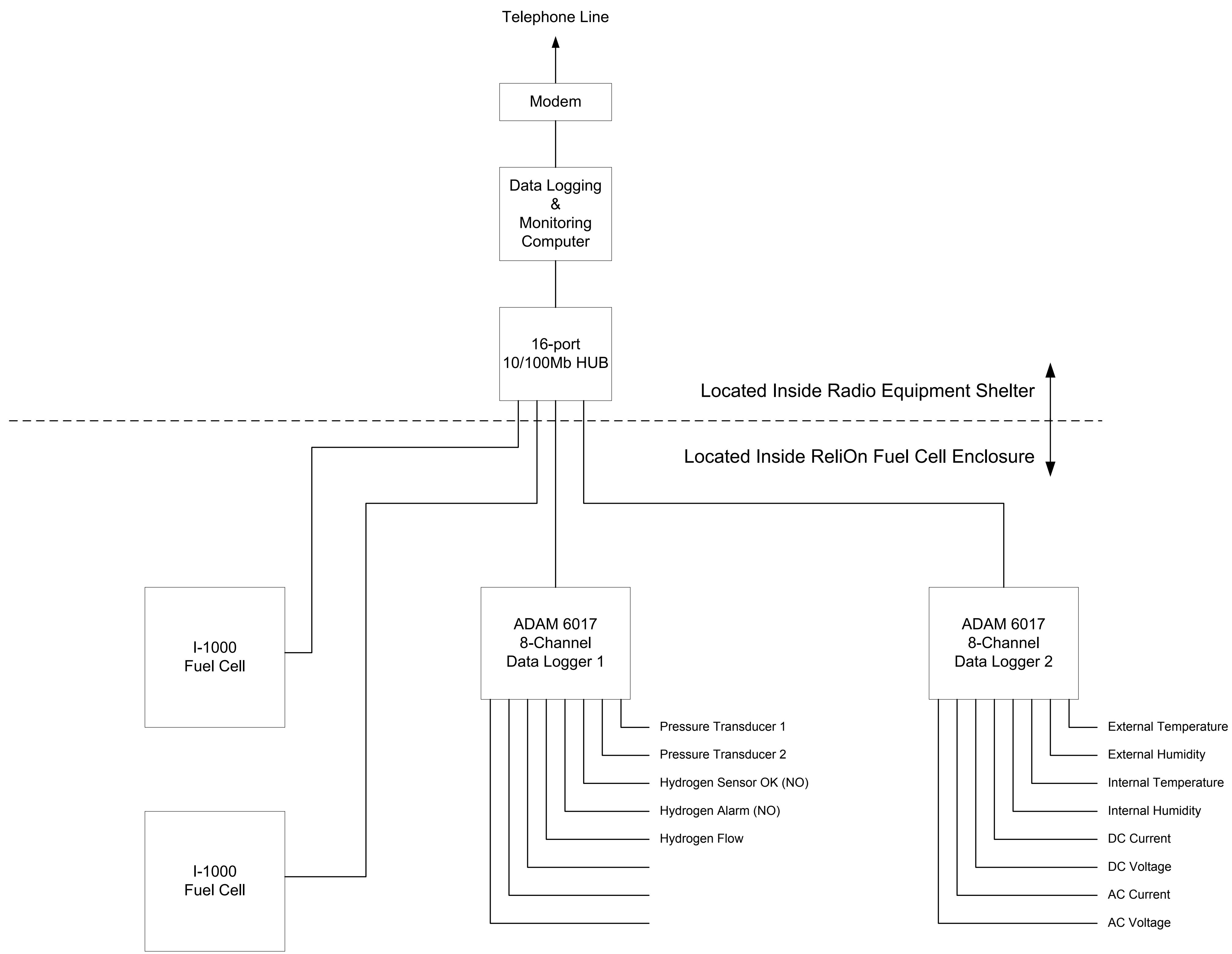



| | |
|---|---|
| PROJECT | CERL IV |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL |
| SITE | DHS Customs & Border Protection, Spokane Sector Headquarters, Washington |
| TITLE | Electrical & Instrumentation |
| FILE | CBP Spkn HQ E&I Rev C.vsd |
| SHEET | 2 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 2 DATA LOGGING BLOCK DIAGRAM

NO SCALE

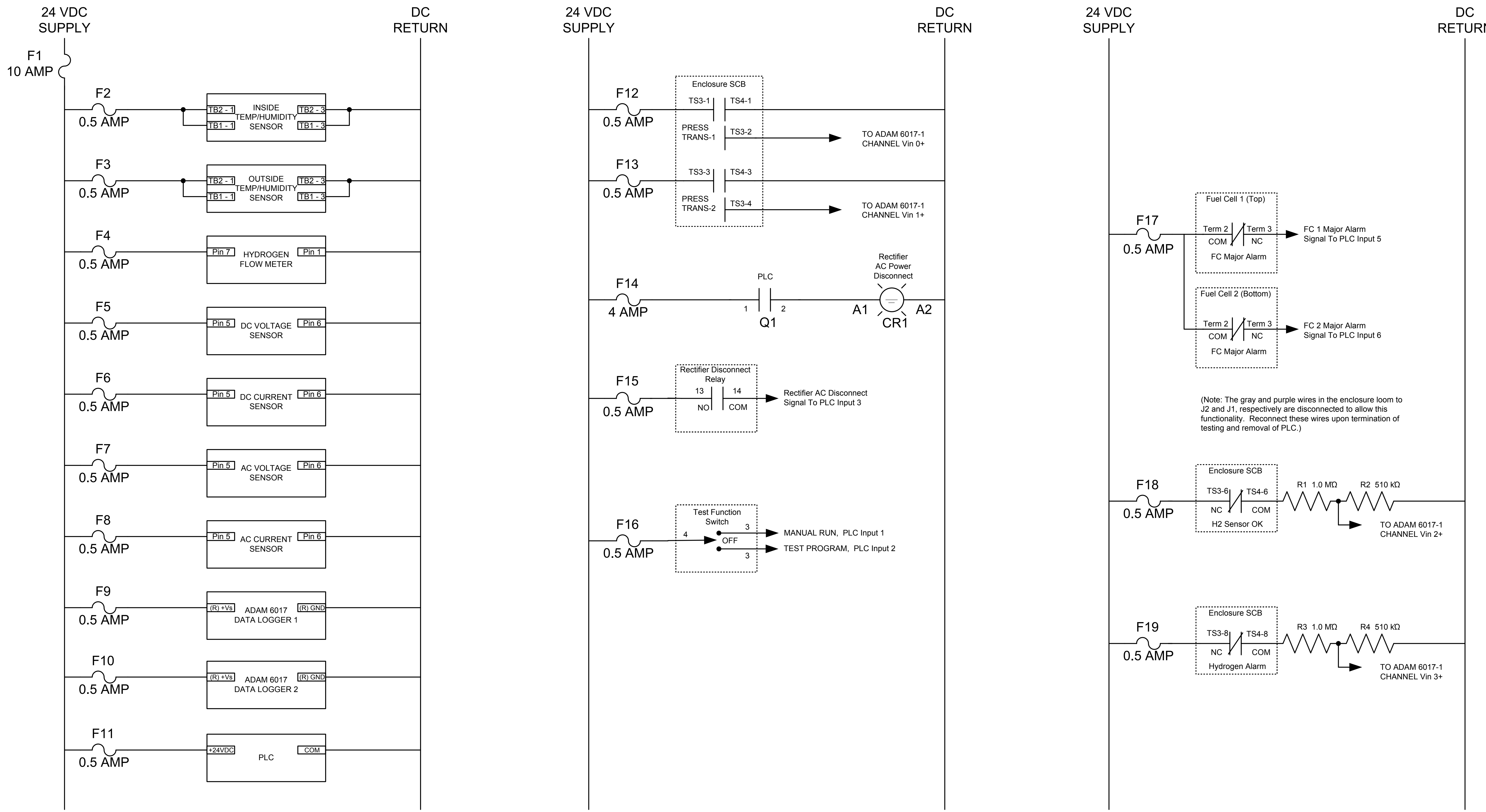



| | | | |
|---|---|---|---|
| ReliOn<br>15913 East Euclid Avenue<br>Spokane, Washington 99216 | NOTICE OF PROPRIETARY INFORMATION<br>The information contained in this document is confidential and considered proprietary to Relion, Inc. Any use, transfer, or duplication of the information contained herein is strictly forbidden without the express written consent of Relion, Inc. | PROJECT CERL IV<br>CUSTOMER Army Corp of Engineers, ERDC/CERL<br>SITE DHS Customs & Border Protection, Spokane Sector Headquarters, Washington | TITLE Electrical & Instrumentation<br>FILE CBP Spkn HQ E&I Rev C.vsd<br>SHEET 3 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 3 TEST INSTRUMENTATION DC SCHEMATIC

NO SCALE




**Notes:**

1. System is designed for +24 VDC.

ReliOn
15913 East Euclid Avenue
Spokane, Washington 99216

NOTICE OF PROPRIETARY INFORMATION



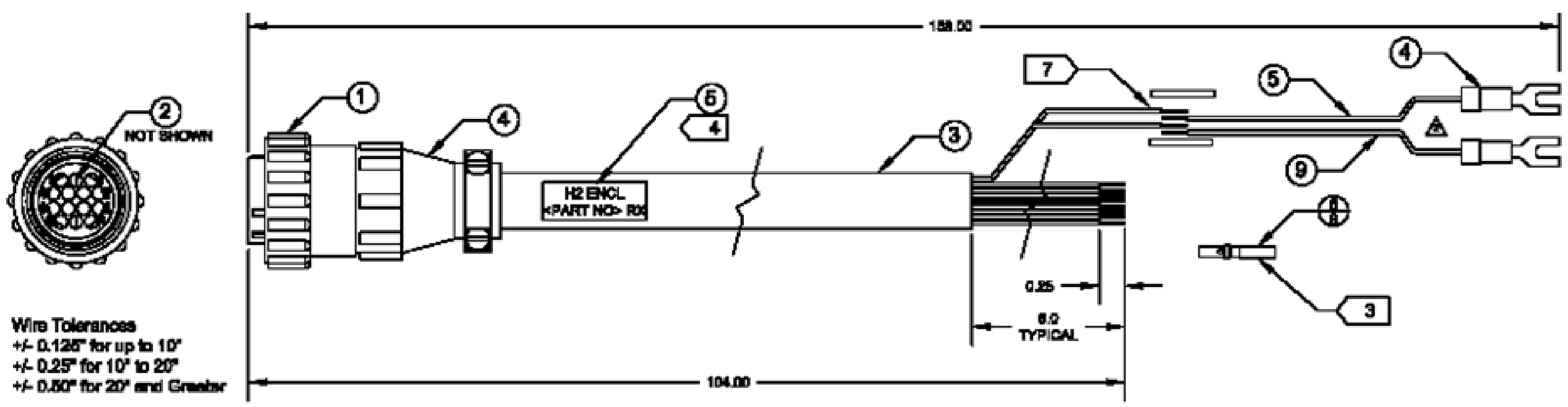
| | | | |
|---|---|---|---|
| PROJECT | CERL IV | TITLE | Electrical & Instrumentation |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL | FILE | CBP Spkn HQ E&I Rev C.vsd |
| SITE | DHS Customs & Border Protection, Spokane Sector Headquarters, Washington | SHEET | 4 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 4 MANIFOLD PRESSURE TRANSDUCER CONNECTIONS

NO SCALE

CABLE, H2 ENCL, W/DIN CONN, J69 (DWG NO. 263-105218)




| WIRE COLOR & CONTACT LEGEND | | | |
|---|---|---|---|
| PIN | COLOR | SIGNAL | TERMINATION |
| 1 | WHITE | PS1 COMMON | SOCKET |
| 2 | RED | PS1 NO | SOCKET |
| 3 | BLACK | PS1 GROUND | SOCKET |
| 4 | BLUE | SOLENOID (-) | N/A |
| 5 | ORANGE | SOLENOID (+) | N/A |
| 6 | GREEN | SOLENOID GROUND | N/A |
| 7 | BROWN | PS1 NC | SOCKET |
| 8 | - | NO CONNECTION | - |
| 9 | PURPLE | DOOR ALARM (NO) | RED WIRE W/FORK TERMINAL |
| 10 | YELLOW | DOOR ALARM (COM) | BLK WIRE W/FORK TERMINAL |
| 11 | RED/GRN | PS2 GROUND | SOCKET |
| 12 | RED/BLK | PS2 COMMON | SOCKET |
| 13 | TAN | PS2 NO | SOCKET |
| 14 | GRAY | PS2 NC | SOCKET |

Notes:

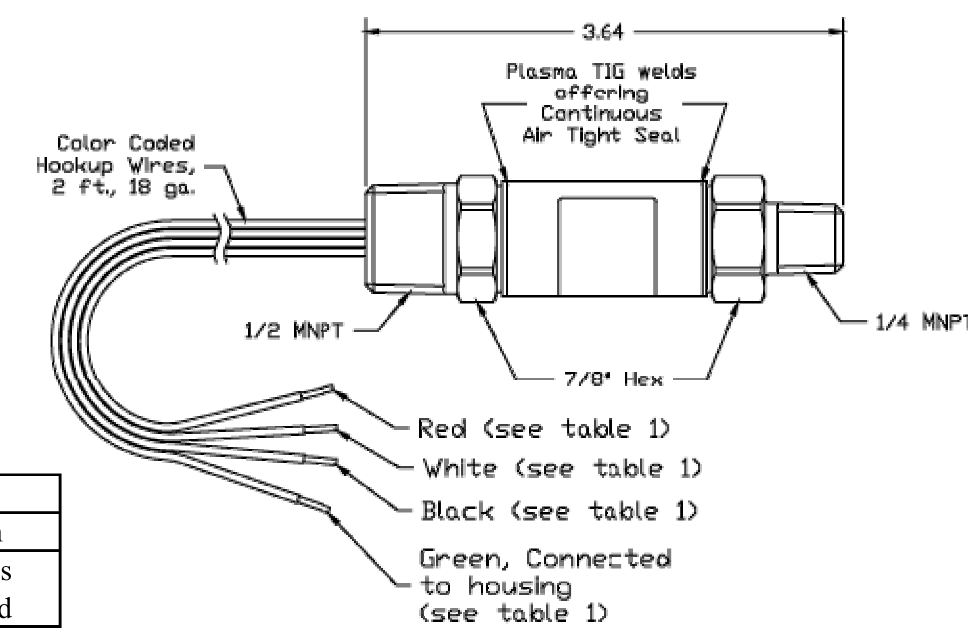
1. Connect Red (+V Supply) wire from pressure transducer to Pin 2 (Red Wire) of H2 Enclosure Cable.

2. Connect Black (-V Supply) wire from pressure transducer to Pin 1 (White Wire) of H2 Enclosure Cable.

3. Connect White (1-5 V Output) wire from pressure transducer to Pin 7 (Brown Wire) of H2 Enclosure Cable.

4. Connect Green (Housing Ground) wire from pressure transducer to Pin 3 (Black Wire) of H2 Enclosure Cable.

American Sensor Technology AST4600 Pressure Transducer

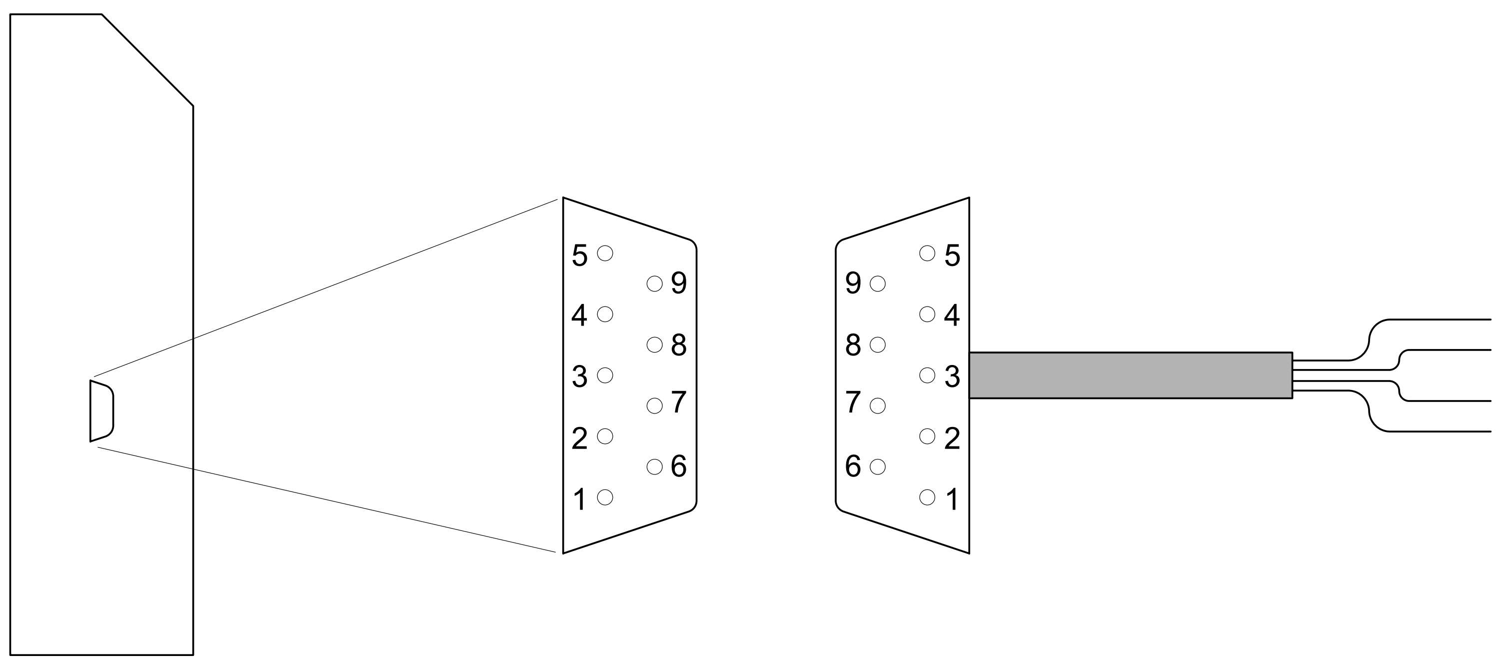



| Table 1--Pressure Transducer Wiring Connections | | | | |
|---|---|---|---|---|
| Output | Red | Black | White | Green |
| 1-5 V | + 10-28 VDC | DC Return | 1-5 V Output Signal | Chassis Ground |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 5 HYDROGEN FLOW METER CONNECTIONS

NO SCALE




Pin 1 - Power Supply DC Return - Black

Pin 4 - Flow Meter 0-5 VDC Output - White (ADAM 6017-1 Channel Vin 4+)

Pin 7 - Power Supply + 24 VDC - Red (Fuse F4)

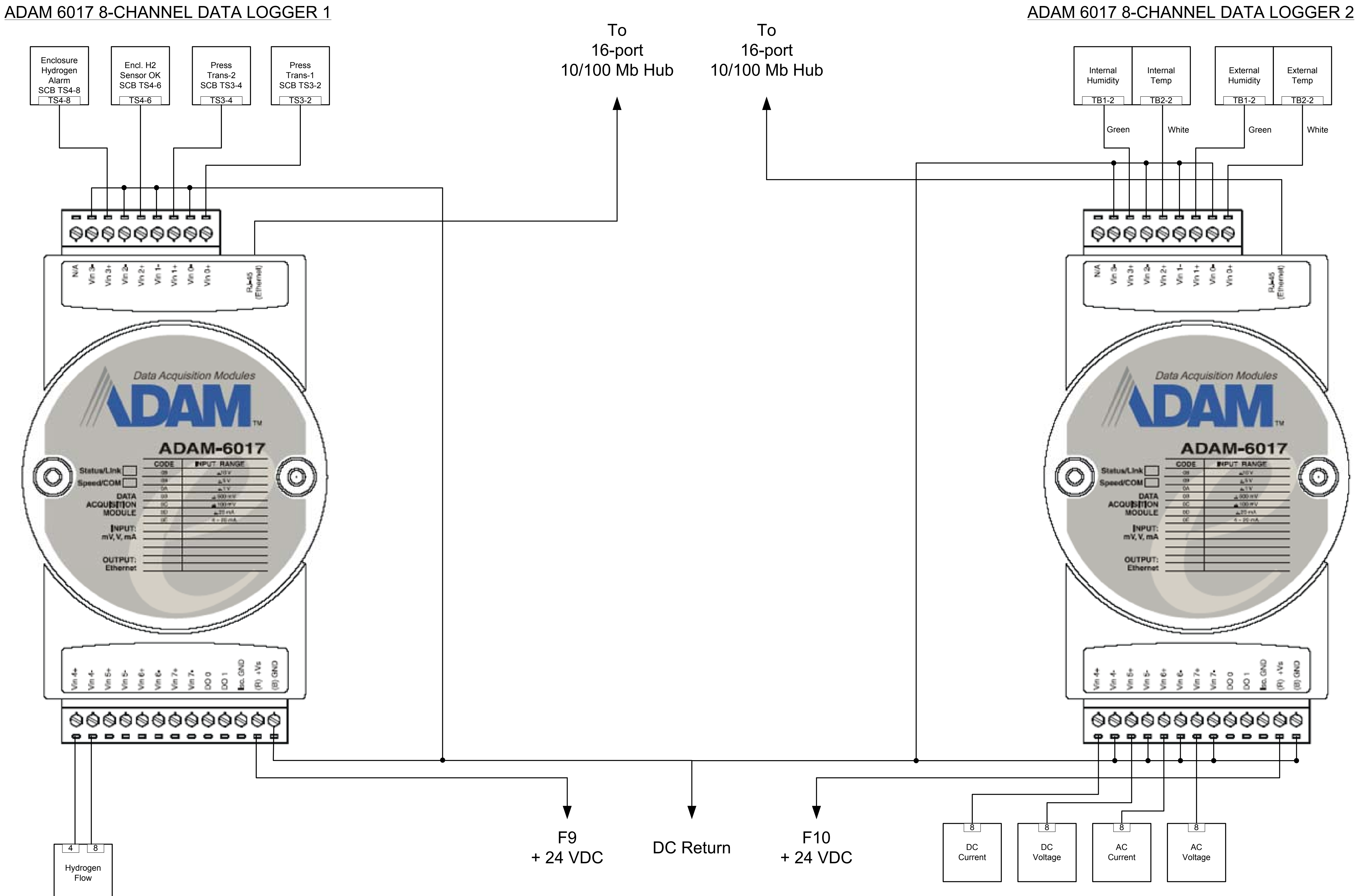
Pin 8 - Flow Meter DC Common Output - Green (ADAM 6017-1 Channel Vin 4-)

| | | | |
|---|---|---|---|
| Reli On<br>15913 East Euclid Avenue<br>Spokane, Washington 99216 | NOTICE OF PROPRIETARY INFORMATION<br>The information contained in this document is confidential and considered proprietary to Relion, Inc. Any use, transfer, or duplication of the information contained herein is strictly forbidden without the express written consent of Relion, Inc. | PROJECT CERL IV<br>CUSTOMER Army Corp of Engineers, ERDC/CERL<br>SITE DHS Customs & Border Protection, Spokane Sector Headquarters, Washington | TITLE Electrical & Instrumentation<br>FILE CBP Spkn HQ E&I Rev C.vsd<br>SHEET 6 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 6 FUEL CELL SYSTEM DATA ACQUISITION WIRING DIAGRAM

NO SCALE

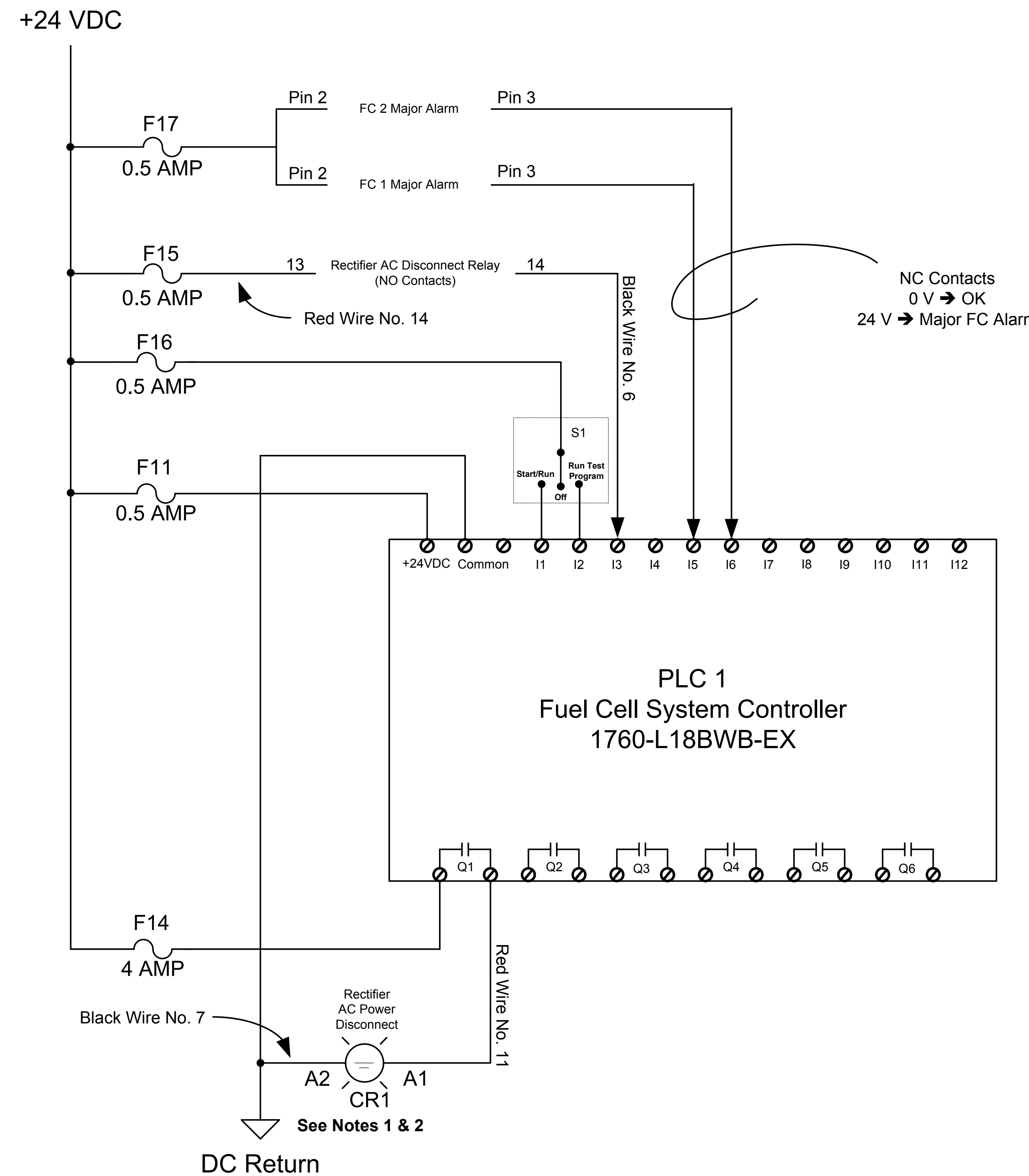



| | | | |
|---|---|---|---|
| ReliOn<br>15913 East Euclid Avenue<br>Spokane, Washington 99216 | NOTICE OF PROPRIETARY INFORMATION<br>The information contained in this document is confidential and considered proprietary to Relion, Inc. Any use, transfer, or duplication of the information contained herein is strictly forbidden without the express written consent of Relion, Inc. | PROJECT: CERL IV<br>CUSTOMER: Army Corp of Engineers, ERDC/CERL<br>SITE: DHS Customs & Border Protection, Spokane Sector Headquarters, Washington | TITLE: Electrical & Instrumentation<br>FILE: CBP Spkn HQ E&I Rev C.vsd<br>SHEET: 7 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 7 PLC CONNECTIONS

NO SCALE




**Notes:**

1. PLC is programmed to simulate an AC power loss to the Shelter Rectifier by energizing normally closed contacts of CR1 and disconnecting the AC power to the Rectifier.

2. AC disconnect relay CR1 Is located in the shelter inside the 6x6x6 pull box.


ReliOn
15913 East Euclid Avenue
Spokane, Washington 99216

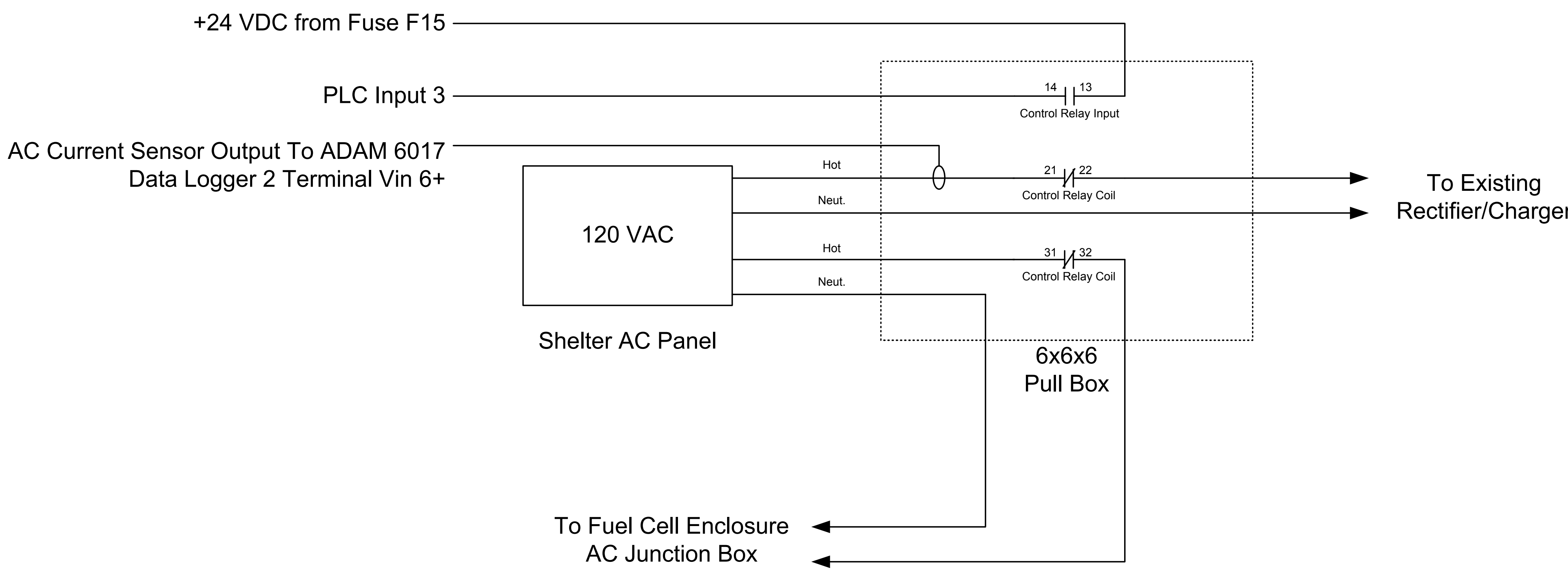



| | | | |
|---|---|---|---|
| PROJECT | CERL IV | TITLE | Electrical & Instrumentation |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL | FILE | CBP Spkn HQ E&I Rev C.vsd |
| SITE | DHS Customs & Border Protection, Spokane Sector Headquarters, Washington | SHEET | 8 of 12 |

# DETAIL 8 RECTIFIER AC DISCONNECT RELAY & AC CURRENT SENSOR CONNECTIONS

NO SCALE

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |




ReliOn
15913 East Euclid Avenue
Spokane, Washington 99216



| | | | |
|---|---|---|---|
| PROJECT | CERL IV | TITLE | Electrical & Instrumentation |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL | FILE | CBP Spkn HQ E&I Rev C.vsd |
| SITE | DHS Customs & Border Protection, Spokane Sector Headquarters, Washington | SHEET | 9 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 9 TEST INSTRUMENT DIN RAIL PLACEMENT

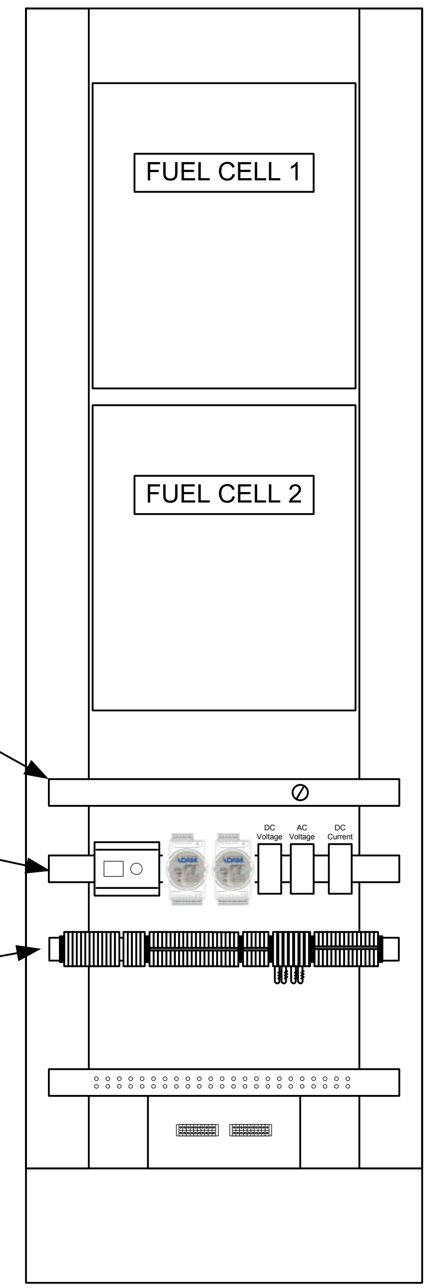
SCALE: 1" = 1' - 0"

Fuel Cell Compartment
Rear View

1U Blank Panel With PLC Test Function Switch S1

½" DIN Rail Test Instrumentation

½" DIN Rail Terminal Blocks

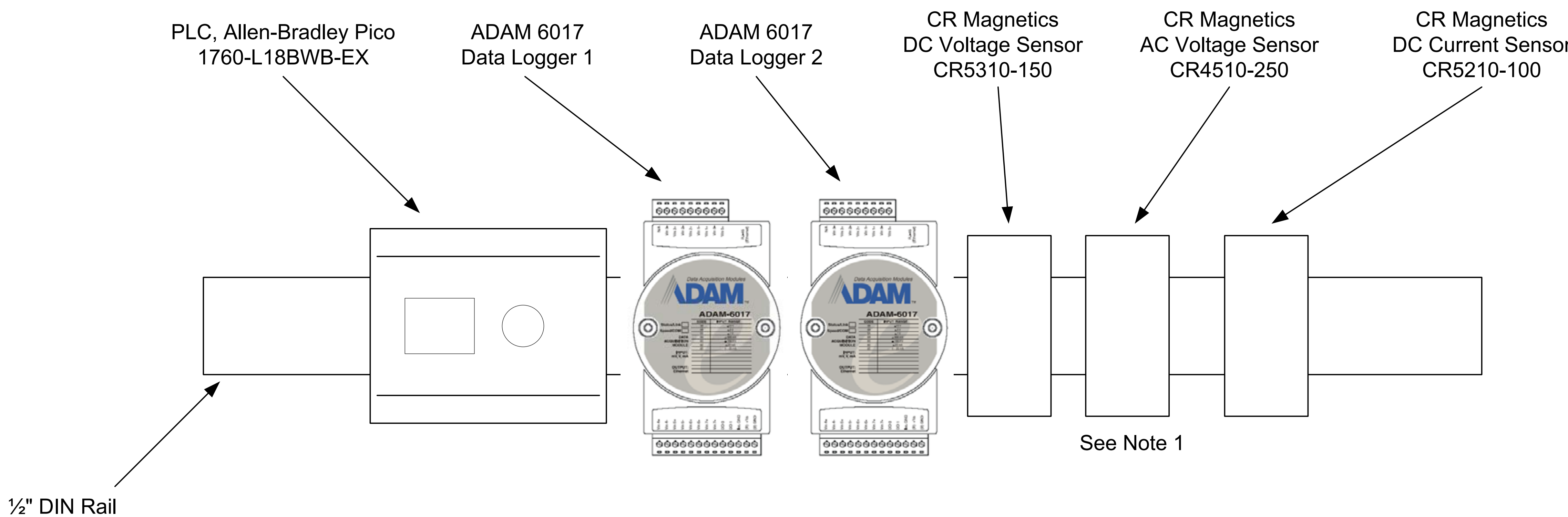



| | | | |
|---|---|---|---|
| ReliOn<br>15913 East Euclid Avenue<br>Spokane, Washington 99216 | NOTICE OF PROPRIETARY INFORMATION<br>The information contained in this document is confidential and considered proprietary to Relion, Inc. Any use, transfer, or duplication of the information contained herein is strictly forbidden without the express written consent of Relion, Inc. | PROJECT CERL IV<br>CUSTOMER Army Corp of Engineers, ERDC/CERL<br>SITE DHS Customs & Border Protection, Spokane Sector Headquarters, Washington | TITLE Electrical & Instrumentation<br>FILE CBP Spkn HQ E&I Rev C.vsd<br>SHEET 10 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 10 TEST INSTRUMENTATION & CONTROL DIN RAIL LAYOUT

NO SCALE




Notes:

1. Connect Terminals 1 and 3 to AC Hot and Neutral, Respectively in Enclosure AC Junction Box


ReliOn
15913 East Euclid Avenue
Spokane, Washington 99216

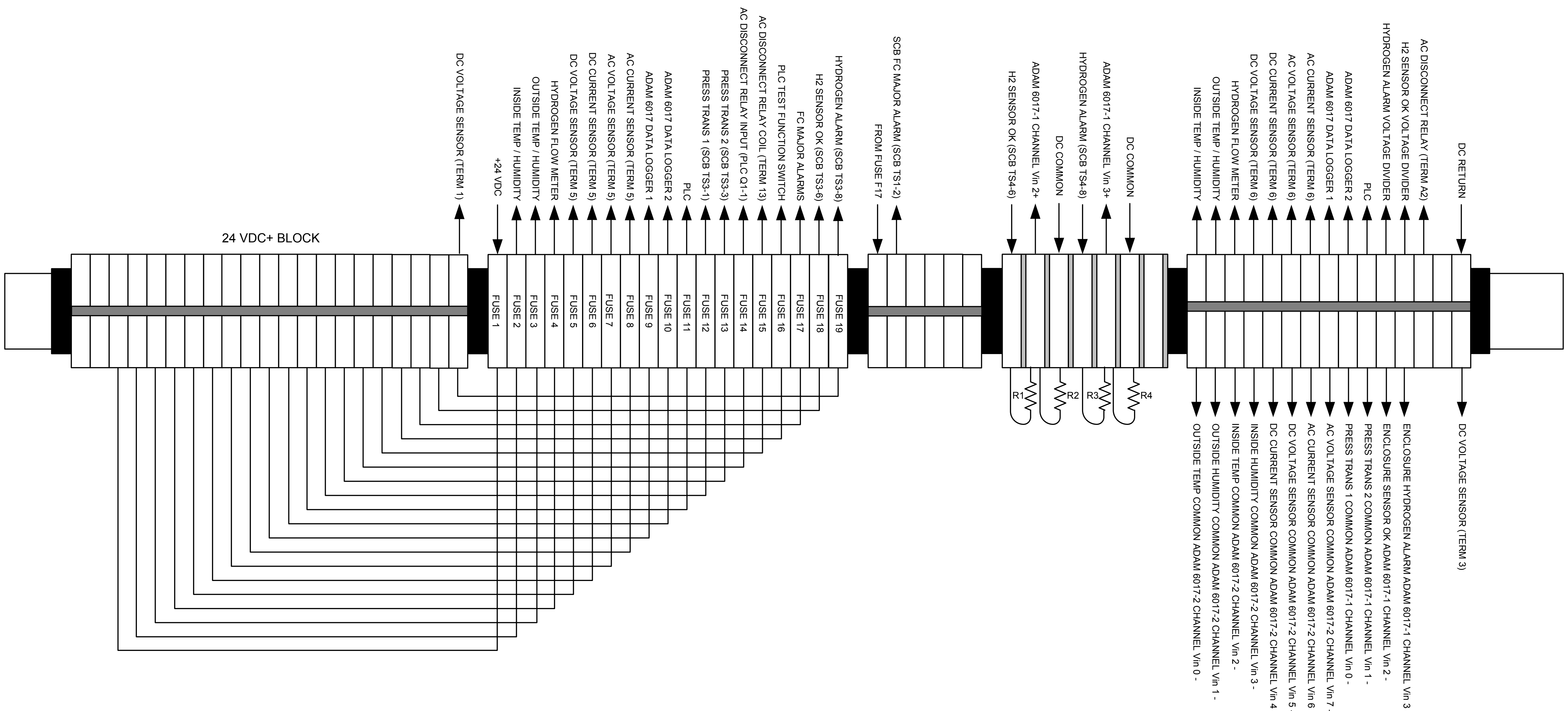



| | | | |
|---|---|---|---|
| PROJECT | CERL IV | TITLE | Electrical & Instrumentation |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL | FILE | CBP Spkn HQ E&I Rev C.vsd |
| SITE | DHS Customs & Border Protection, Spokane Sector Headquarters, Washington | SHEET | 11 of 12 |

| REV | DESCRIPTION | DATE | ENG | DFT |
|---|---|---|---|---|
| A | First Issue | 08-08-2005 | GCS | GCS |
| B | As Built | 10-21-2005 | GCS | GCS |
| C | Modified PLC Alarm Wiring | 04-25-2006 | GCS | GCS |

# DETAIL 11 TEST INSTRUMENTATION TERMINAL BLOCK
# DIN RAIL CONNECTION LAYOUT

NO SCALE





Reli On
15913 East Euclid Avenue
Spokane, Washington 99216




| | |
|---|---|
| PROJECT | CERL IV |
| CUSTOMER | Army Corp of Engineers, ERDC/CERL |
| SITE | DHS Customs & Border Protection, Spokane Sector Headquarters, Washington |
| TITLE | Electrical & Instrumentation |
| FILE | CBP Spkn HQ E&I Rev C.vsd |
| SHEET | 12 of 12 |

Appendix 3

Monthly Performance Data - June 2006 thru May 2007

Site 1 – Mica Peak
Site 2 – Sector HQ

**ReliOn PEM Fuel Cell Performance Data**

| | | | | | |
|---|---|---|---|---|---|
| **System Number:** | **4-1** | **Commission Date:** | **1-Nov-05** | **Site Location(City,State):** | **Mica Peak, WA** |
| **Site Name:** | **Mica Peak** | **Start of 1 Year Test Program:** | **1-Jun-06** | | |
| **Fuel Type:** | **Hydrogen** | **Fuel Cell Type:** | **Modular PEM** | | |
| **Lower Heating Value:** | **266.6 (Btu/scf)** | **Maintenance Contractor:** | **ReliOn, Inc.** | | |
| **Lower Heating Value:** | **9.72 (kJ/liter)** | **Local Residential Fuel Cost per therm:** | N/A **$/therm** | **Local Base Fuel Cost per therm:** | N/A **$/therm** |
| **Capacity kW** | **3** | **Local Residential Electricity Cost per kWhr:** | N/A **$/kWhr** | **Local Base Electricity Cost per kWhr** | N/A **$/kWhr** |

| Month | Total Time in Month | Total Run Time During Month | Total Run Time During Scheduled Test Periods (Note 1) | | | Attempted Starts | Actual Starts | Availability (Note 2) | Reliability (Note 3) | Net Energy Produced | Plant Capacity | Average Output (Note 4) | Capacity Factor (Note 5) | Fuel Usage | | Electrical Efficiency (Note 6) | Thermal Heat Recovery | Heat Recovery Rate (Note 7) | Thermal Efficiency (Note 8) | Overall Efficiency (Note 9) | Number of Scheduled Outages | Scheduled Outage Hours | Number of Unscheduled Outages | Unscheduled Outage Hours | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Hours) | (Hours) | (Hours) Scheduled | (Hours) Actual | (Hours) Cumulative | | | (%) | (%) | (kWe-hr) | (kW) | (kWe) | (%) | (liters) | (kJ, LHV) | (%, LHV) | (kJ) | (kWth) | (%, LHV) | (%, LHV) | | (Hours) | | (Hours) | |
| Jun 2006 | 720 | 30.0 | 30.0 | 30.0 | 30.0 | 30 | 30 | 100% | 100% | 12.35 | 3 | 0.412 | 0.57% | 19218.6 | 186804.5 | 23.80% | 0.0 | 0.00 | 0.00% | 23.80% | 0 | 0.00 | 0 | 0.00 | 17,18 |
| Jul 2006 | 744 | 31.0 | 31.0 | 31.0 | 61.0 | 31 | 31 | 100% | 100% | 15.59 | 3 | 0.503 | 0.70% | 23216.2 | 225661.8 | 24.86% | 0.0 | 0.00 | 0.00% | 24.86% | 0 | 0.00 | 0 | 0.00 | |
| Aug 2006 | 744 | 31.0 | 31.0 | 31.0 | 92.0 | 31 | 31 | 100% | 100% | 26.72 | 3 | 0.862 | 1.20% | 33856.0 | 329080.6 | 29.23% | 0.0 | 0.00 | 0.00% | 29.23% | 0 | 0.00 | 0 | 0.00 | |
| Sep 2006 | 720 | 30.0 | 30.0 | 30.0 | 122.0 | 30 | 30 | 100% | 100% | 25.98 | 3 | 0.866 | 1.20% | 32317.4 | 314125.3 | 29.77% | 0.0 | 0.00 | 0.00% | 29.77% | 0 | 0.00 | 0 | 0.00 | |
| Oct 2006 | 744 | 31.0 | 31.0 | 31.0 | 153.0 | 31 | 31 | 100% | 100% | 26.24 | 3 | 0.846 | 1.18% | 32055.1 | 311576.0 | 30.32% | 0.0 | 0.00 | 0.00% | 30.32% | 0 | 0.00 | 0 | 0.00 | |
| Nov 2006 | 720 | 30.0 | 30.0 | 30.0 | 183.0 | 31 | 31 | 100% | 100% | 26.12 | 3 | 0.871 | 1.21% | 31749.1 | 308601.0 | 30.47% | 0.0 | 0.00 | 0.00% | 30.47% | 0 | 0.00 | 0 | 0.00 | 19 |
| Dec 2006 | 744 | 31.0 | 31.0 | 31.0 | 214.0 | 31 | 31 | 100% | 100% | 27.25 | 3 | 0.879 | 1.22% | 34580.7 | 336124.8 | 29.18% | 0.0 | 0.00 | 0.00% | 29.18% | 0 | 0.00 | 0 | 0.00 | |
| Jan 2007 | 744 | 31.0 | 31.0 | 31.0 | 245.0 | 31 | 31 | 100% | 100% | 27.37 | 3 | 0.883 | 1.23% | 34079.0 | 331247.4 | 29.75% | 0.0 | 0.00 | 0.00% | 29.75% | 0 | 0.00 | 0 | 0.00 | |
| Feb 2007 | 672 | 28.0 | 28.0 | 28.0 | 273.0 | 28 | 28 | 100% | 100% | 24.47 | 3 | 0.874 | 1.21% | 29412.4 | 285888.2 | 30.81% | 0.0 | 0.00 | 0.00% | 30.81% | 0 | 0.00 | 0 | 0.00 | |
| Mar 2007 | 744 | 31.0 | 31.0 | 31.0 | 304.0 | 31 | 31 | 100% | 100% | 26.28 | 3 | 0.848 | 1.18% | 31287.6 | 304115.1 | 31.11% | 0.0 | 0.00 | 0.00% | 31.11% | 0 | 0.00 | 0 | 0.00 | |
| Apr 2007 | 720 | 30.0 | 30.0 | 30.0 | 30.0 | 30 | 30 | 100% | 100% | 26.20 | 3 | 0.873 | 1.21% | 31434.6 | 305544.4 | 30.87% | 0.0 | 0.00 | 0.00% | 30.87% | 0 | 0.00 | 0 | 0.00 | |
| May 2007 | 744 | 31.0 | 31.0 | 31.0 | 31.0 | 31 | 31 | 100% | 100% | 26.98 | 3 | 0.870 | 1.21% | 33218.2 | 322881.4 | 30.08% | 0.0 | 0.00 | 0.00% | 30.08% | 0 | 0.00 | 0 | 0.00 | 20 |

| Running Totals | Total Time in Month | Total Run Time During Month | Total Run Time During Scheduled Test Periods | | | Total Attempted Starts | Total Actual Starts | Total Availability (Note 8) | Total Reliability | Total Energy Produced | Plant Capacity | Total Average Output (Note 11) | Total Capacity Factor (Note 12) | Fuel Usage | | Average Electrical Efficiency (Note 13) | Total Thermal Heat Recovery | Heat Recovery Rate (Note 14) | Thermal Efficiency (Note 15) | Overall Efficiency (Note 16) | Total Number of Scheduled Outages | Total Scheduled Outage Hours | Total Number of Unscheduled Outages | Total Unscheduled Outage Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Hours) | (Hours) | (Hours) Scheduled | (Hours) Actual | (Hours) Cumulative | | | (%) | (%) | (kWe-hr) | (kW) | (kWe) | (%) | (liters) | (kJ, LHV) | (%, LHV) | (kJ) | (kWth) | (%, LHV) | (%, LHV) | | (Hours) | | (Hours) |
| | 8760 | 365.0 | 365.0 | 365.0 | 365.0 | 366.0 | 366.0 | 100.0% | 100.0% | 291.54 | 3 | 0.799 | 1.11% | 366424.9 | 3561650.5 | 29.47% | 0.0 | 0.00 | 0.00% | 29.47% | 0 | 0.00 | 0 | 0.00 |

Notes:

| | | | |
|---|---|---|---|
| 1 | Includes Scheduled Test Runs & Run Time During Loss of AC Grid | | |
| 2 | Availability | = | Actual Run Time in Period / Scheduled Run Time in Period |
| 3 | Reliability | = | Actual Starts / Attempted Starts (Includes Test Starts & Loss of Grid Power Automatic Starts) |
| 4 | Average Output | = | Energy Produced / Run Time |
| 5 | Capacity Factor | = | Energy Produced / (Capacity * Time in Period) |
| 6 | Electrical Efficiency | = | Net Energy Produced / Fuel Usage |
| 7 | Heat Recovery Rate | = | Thermal Heat Recovery / Run Time |
| 8 | Thermal Efficiency | = | Thermal Heat Recovery / Fuel Usage |
| 9 | Overall Efficiency | = | Electrical Efficiency + Thermal Efficiency |
| 10 | Total Availability | = | Sum Total Run Time / Sum Total Hours in Period |
| 11 | Total Average Output | = | Total Energy Produced / Total Run Time |
| 12 | Total Capacity Factor | = | Total Energy Produced / (Total Capacity * Total Time in Period) |
| 13 | Avg. Electrical Efficiency | = | Total net energy produced / Total Fuel Usage |
| 14 | Avg. Heat Recovery Rate | = | Total Thermal Heat Recovery / Total Run Time |
| 15 | Avg. Thermal Efficiency | = | Total Thermal Heat Recovery / Total Fuel Usage |
| 16 | Avg. Overall Efficiency | = | Avg. Electrical Efficiency + Avg. Thermal Efficiency |

17 Acceptance testing conducted in May
18 Test program commissioned June 1st
19 11/13/06 there was an 1 minute 13 second Grid Power outage at 8:12:59 AM
20 Test program completed on May 31, 2007 for CERL 4-1, Mica Peak. No more reporting is required.

## ReliOn PEM Fuel Cell Performance Data

| | | | | | |
|---|---|---|---|---|---|
| **System Number:** | **4-2** | | **Commission Date:** | **1-Nov-05** | |
| **Site Name:** | **Boreder Patrol HQ** | | **Start of 1 Year Test Program:** | **1-Jun-06** | |
| **Fuel Type:** | **Hydrogen** | | **Fuel Cell Type:** | **Modular PEM** | |
| **Lower Heating Value:** | **2.66** | **(Btu/scf)** | **Maintenance Contractor:** | **ReliOn, Inc.** | |
| **Lower Heating Value:** | **9.72** | **(kJ/liter)** | **Local Residential Fuel Cost per therm:** | N/A | **$/therm** |
| **Capacity kW** | **2** | | **Local Residential Electricity Cost per kWhr:** | N/A | **$/kWhr** |

| | | |
|---|---|---|
| **Site Location(City,State):** | **Spokane, WA** | |
| **Local Base Fuel Cost per therm:** | N/A | **$/therm** |
| **Local Base Electricity Cost per kWhr** | N/A | **$/kWhr** |

| Month | Total Time in Month | Total Run Time During Month | Total Run Time During Scheduled Test Periods (Note 1) | | | Attempted Starts | Actual Starts | Availability (Note 2) | Reliability (Note 3) | Net Energy Produced | Plant Capacity | Average Output (Note 4) | Capacity Factor (Note 5) | Fuel Usage | | Electrical Efficiency (Note 6) | Thermal Heat Recovery | Heat Recovery Rate (Note 7) | Thermal Efficiency (Note 8) | Overall Efficiency (Note 9) | Number of Scheduled Outages | Scheduled Outage Hours | Number of Unscheduled Outages | Unscheduled Outage Hours | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Hours) | (Hours) | (Hours) Scheduled | (Hours) Actual | (Hours) Cumulative | | | (%) | (%) | (kWe-hr) | (kW) | (kWe) | (%) | (liters) | (kJ, LHV) | (%, LHV) | (kJ) | (kWth) | (%, LHV) | (%, LHV) | | (Hours) | | (Hours) | |
| Jun 2006 | 720 | 30.0 | 30.0 | 30.0 | 30.0 | 30 | 30 | 100% | 100% | 18.66 | 2 | 0.622 | 1.30% | 22412.3 | 217847.4 | 30.83% | 0.0 | 0.00 | 0.00% | 30.83% | 0 | 0.00 | 0 | 0.00 | 17,18 |
| Jul 2006 | 744 | 31.0 | 31.0 | 31.0 | 61.0 | 31 | 31 | 100% | 100% | 20.17 | 2 | 0.651 | 1.36% | 25853.1 | 251292.3 | 28.90% | 0.0 | 0.00 | 0.00% | 28.90% | 0 | 0.00 | 0 | 0.00 | |
| Aug 2006 | 744 | 31.0 | 31.0 | 31.0 | 92.0 | 31 | 31 | 100% | 100% | 19.77 | 2 | 0.638 | 1.33% | 24382.8 | 237000.9 | 30.02% | 0.0 | 0.00 | 0.00% | 30.02% | 0 | 0.00 | 0 | 0.00 | |
| Sep 2006 | 720 | 30.0 | 30.0 | 30.0 | 122.0 | 30 | 30 | 100% | 100% | 18.59 | 2 | 0.620 | 1.29% | 21067.9 | 204780.2 | 32.68% | 0.0 | 0.00 | 0.00% | 32.68% | 0 | 0.00 | 0 | 0.00 | |
| Oct 2006 | 744 | 31.0 | 31.0 | 31.0 | 153.0 | 31 | 31 | 100% | 100% | 18.88 | 2 | 0.609 | 1.27% | 21684.8 | 210776.5 | 32.25% | 0.0 | 0.00 | 0.00% | 32.25% | 0 | 0.00 | 0 | 0.00 | |
| Nov 2006 | 720 | 30.0 | 30.0 | 30.0 | 183.0 | 30 | 30 | 100% | 100% | 18.11 | 2 | 0.604 | 1.26% | 20629.5 | 200519.1 | 32.52% | 0.0 | 0.00 | 0.00% | 32.52% | 0 | 0.00 | 0 | 0.00 | |
| Dec 2006 | 744 | 31.0 | 31.0 | 31.0 | 214.0 | 31 | 31 | 100% | 100% | 18.74 | 2 | 0.605 | 1.26% | 21023.0 | 204344.0 | 33.02% | 0.0 | 0.00 | 0.00% | 33.02% | 0 | 0.00 | 0 | 0.00 | |
| Jan 2007 | 744 | 28.0 | 31.0 | 28.0 | 242.0 | 31 | 28 | 90% | 90% | 17.06 | 2 | 0.609 | 1.15% | 19058.9 | 185252.2 | 33.14% | 0.0 | 0.00 | 0.00% | 33.14% | 0 | 0.00 | 0 | 0.00 | 19 |
| Feb 2007 | 672 | 28.0 | 28.0 | 28.0 | 270.0 | 28 | 28 | 100% | 100% | 17.10 | 2 | 0.611 | 1.27% | 19636.8 | 190869.3 | 32.26% | 0.0 | 0.00 | 0.00% | 32.26% | 0 | 0.00 | 0 | 0.00 | |
| Mar 2007 | 744 | 31.0 | 31.0 | 31.0 | 301.0 | 31 | 31 | 100% | 100% | 18.97 | 2 | 0.612 | 1.28% | 21729.7 | 211213.1 | 32.34% | 0.0 | 0.00 | 0.00% | 32.34% | 0 | 0.00 | 0 | 0.00 | |
| Apr 2007 | 720 | 30.0 | 30.0 | 30.0 | 331.0 | 30 | 30 | 100% | 100% | 18.32 | 2 | 0.611 | 1.27% | 21630.5 | 210248.8 | 31.37% | 0.0 | 0.00 | 0.00% | 31.37% | 0 | 0.00 | 0 | 0.00 | |
| May 2007 | 744 | 35.8 | 31.0 | 31.0 | 362.0 | 31 | 31 | 100% | 100% | 22.60 | 2 | 0.729 | 1.52% | 27024.4 | 262676.8 | 30.97% | 0.0 | 0.00 | 0.00% | 30.97% | 0 | 0.00 | 0 | 0.00 | 20,21 |

| Running Totals | Total Time in Month | Total Run Time During Month | Total Run Time During Scheduled Test Periods | | | Total Attempted Starts | Total Actual Starts | Total Availability (Note 8) | Total Reliability | Total Energy Produced | Plant Capacity | Total Average Output (Note 11) | Total Capacity Factor (Note 12) | Fuel Usage | | Average Electrical Efficiency (Note 13) | Total Thermal Heat Recovery | Heat Recovery Rate (Note 14) | Thermal Efficiency (Note 15) | Overall Efficiency (Note 16) | Total Number of Scheduled Outages | Total Scheduled Outage Hours | Total Number of Unscheduled Outages | Total Unscheduled Outage Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (Hours) | (Hours) | (Hours) Scheduled | (Hours) Actual | (Hours) Cumulative | | | (%) | (%) | (kWe-hr) | (kW) | (kWe) | (%) | (liters) | (kJ, LHV) | (%, LHV) | (kJ) | (kWth) | (%, LHV) | (%, LHV) | | (Hours) | | (Hours) |
| | 8760 | 366.8 | 365.0 | 362.0 | 362.0 | 365.0 | 362.0 | 99.2% | 99.2% | 226.98 | 2 | 0.627 | 1.30% | 266133.8 | 2586820.7 | 31.59% | 0.0 | 0.00 | 0.00% | 31.59% | 0 | 0.00 | 0 | 0.00 |

Notes:

1 Includes Scheduled Test Runs & Run Time During Loss of AC Grid
2 Availability = Actual Run Time in Period / Scheduled Run Time in Period
3 Reliability = Actual Starts / Attempted Starts (Includes Test Starts & Loss of Grid Power Automatic Starts)
4 Average Output = Energy Produced / Run Time
5 Capacity Factor = Energy Produced / (Capacity * Time in Period)
6 Electrical Efficiency = Net Energy Produced / Fuel Usage
7 Heat Recovery Rate = Thermal Heat Recovery / Run Time
8 Thermal Efficiency = Thermal Heat Recovery / Fuel Usage
9 Overall Efficiency = Electrical Efficiency + Thermal Efficiency

10 Total Availability = Sum Total Run Time / Sum Total Hours in Period
11 Total Average Output = Total Energy Produced / Total Run Time
12 Total Capacity Factor = Total Energy Produced / (Total Capacity * Total Time in Period)
13 Avg. Electrical Efficiency = Total net energy produced / Total Fuel Usage
14 Avg. Heat Recovery Rate = Total Thermal Heat Recovery / Total Run Time
15 Avg. Thermal Efficiency = Total Thermal Heat Recovery / Total Fuel Usage
16 Avg. Overall Efficiency = Avg. Electrical Efficiency + Avg. Thermal Efficiency

17 Acceptance testing conducted in May
18 Test program commissioned June 1st

19 Manaul intervetion caused from 1/5/07 site visit caused system not to start on 1/6, 1/7 & 1/8. This issues started on a (Saturday 1/6/07) weekend. System check on morning of 1/8/07 prompted site visit and determination that system was placed in remote status incorrectly. System was reset and tested remotelly and manually resulting in no failures or alarms.
20 5/24/07 - durinig the normal test run window, there was grid power outage that caused the fuel cell to carry the site load an additonal 4 hours and 45 minutes. The grid power came back at roughly 14:45PM PST. This outage was confirmed by a call to HQ.
21 Test program completed on May 31, 2007 for CERL 4-1, Mica Peak. No more reporting is required.

# Appendix 4

## Commissioning Procedures for I-1000 Fuel Cell & outdoor Enclosure

**ReliOn, Inc.**
15913 E. Euclid Ave.
Spokane, Washington 99216
Telephone 509-228-6500
Facsimile 509-228-6510
www.relion-inc.com

# SERVICE GUIDE SG04-15

8/30/04

## Commissioning Procedures for the I-1000™ Fuel Cell & Outdoor Enclosure System

**Objective:** Evaluate fuel cell start-up and shut-down reliability and verification of alarm system functionality. Confirm fuel cell system contribution to power reliability at the site.

**Commissioning Procedure 1**
Check for hydrogen leaks at all hydrogen connections with handheld hydrogen detector (or commercially available soap solution can be used).
Suggested test points:

1. Cylinder connections
2. Manifold and hydrogen cabinet piping joints
3. Equipment cabinet piping joints
4. Fuel feed connection

NOTE: Commissioning Procedure 1 should also be performed when hydrogen cylinders are replaced.

**Commissioning Procedure 2**
Ensure DC bus power has been properly connected to the enclosure DC power terminals. Ensure AC circuit has been properly connected to the circuit breaker, disconnect, or junction box in the enclosure. Activate AC power to the fuel cell enclosure. Close the DC disconnect between the battery bank and the fuel cell enclosure. Verify correct DC voltage level at the enclosure DC power terminals.

**Commissioning Procedure 3**
Record hydrogen cylinder pressure gauges in Bay 1 ($P_1$) and Bay 2 ($P_3$).

**Commissioning Procedure 4**
Perform a manual fuel cell system start by setting fuel cell selector switch to "on" position. Verify fuel cell initiates start up and completes initialization (check for voltage on fuel cell LCD screen). Allow the fuel cell to run until voltage, current, and power levels on the LCD screen stabilizes. A fully charged battery bank will not demand a significant current flow. Therefore the power output of the fuel cell during this procedure probably be low.

**Commissioning Procedure 5**

Simulate a loss of AC power to the site.

1. Deactivate AC circuit breaker (located on the main panel in the equipment shelter).
2. Verify fuel cell initiates start up and completes initialization (check for voltage on fuel cell LCD screen).
3. Allow system to run to accumulate a total run time of at least 30 minutes.
4. Activate AC circuit breaker feeding power to the fuel cell system.
5. Verify fuel cell returns to standby state at fuel cell LCD screen.

**Commissioning Procedure 6**

The regulated pressure should be set between 25-75 psig. The optimal setting for fuel delivery pressure is 40-50 psig. By adjusting the regulated pressures so that one bay is 5-10 psig higher than the other side, hydrogen will flow out of the higher side only until those cylinders are exhausted. The system will then draw hydrogen from the other side allowing time to order and replace the depleted cylinders. The regulated pressure should be adjusted to 50 psig in Bay 1 and 40 psig in Bay 2 following initial installation of the cylinders or when they are replenished. During normal operation and post-run standby periods, the higher regulated pressure in Bay 1 will feedback to the regulated pressure gauge in Bay 2. As a result, the regulated pressure gauges on both sides will read the higher pressure (50 psig) even when correctly adjusted. Note that check valves are designed into the system to prevent gas flow from the high pressure side to the low pressure side. The regulated pressures in each bay can be correctly checked and adjusted with the following procedures.

1. Manually start the fuel cell by setting fuel cell selector switch to "on" position.
2. Verify fuel cell initiates start up and completes initialization (check for voltage on fuel cell LCD screen).
3. Record Bay 1 regulated pressure ($P_2$) and adjust to 50 psig if necessary.
4. Record Bay 2 regulated pressure ($P_4$) by closing the manual shutoff valve (located below the solenoid valve) in Bay 1 until the fuel cell(s) begin to draw hydrogen from Bay 2. When the pressure stabilizes, the regulated pressure set point can be correctly read and adjusted to 40 psig if necessary.
5. Following this verification of the lower regulated pressure set point, the manual shutoff valve in Bay 1 can be re-opened.
6. Continue running the fuel cell in manual mode with the selector switch in the "on" position and proceed to Commissioning Procedure 7.

**Commissioning Procedure 7**

1. Continue from Commissioning Procedure 6 with the fuel cell operating in manual mode. If off, manually start the fuel cell by setting fuel cell selector switch to “on” position and verify operation as before.
2. Remove one 650 series cartridge, confirm minor alarm activates.
3. Re-insert 650 series cartridge, confirm minor alarm clears.
4. Remove three 650 series cartridges, confirm major alarm activates.
5. Observe three attempts to restart followed by shutdown.
6. Re-insert the three 650 series cartridges, confirm major alarm clears.
7. Return fuel cell selector switch to “remote” position.

**Commissioning Procedure 8**

Inspect air filters (on enclosure door and at rear of fuel cell) and clean if necessary; clean per procedure in I-1000 Operating Manual.

**Commissioning Procedure 9**

Simulate DC Bus failure at the site (complete loss of rectifier/charger). {This was accomplished by setting the branch circuit breaker at the main power panel to “off” position for the rectifier/charger}.

1. Connect a digital multimeter to measure and record the DC Bus voltage ($V_{dc1}$).
2. Simulate DC Bus failure by disconnecting AC power to DC Bus system or alternatively shutting down the DC Bus system.
3. Monitor the DC Bus voltage and record the elapsed time ($T_1$) until DC Bus drops to fuel cell DC voltage start-up set point ($V_{dc2}$ ); trip point setting should be 25 Vdc.
4. Verify fuel cell initiates start-up when the DC voltage trip point is reached (check for voltage on fuel cell LCD screen).
5. Record the DC Bus voltage at time of fuel cell startup ($V_{dc2}$).
6. Record time from fuel cell initialization to fuel cell producing power ($T_2$); fuel cell is producing power when the fuel cell LCD screen indicates a positive current.
7. Record the maximum current produced by fuel cell ($I_1$) and time at which the maximum current occurs ($T_3$).
8. Initiate restoration from simulated DC Bus system failure.
9. Monitor the DC Bus voltage and record the elapsed time until fuel cell shuts down ($T_4$).
10. Record the DC Bus voltage at time of fuel cell shutdown ($V_{dc3}$).

**Notes:**

1. **Fuel cell selector switch should remain in "remote" position at all times (except during Commissioning Procedures 6 and 7).**
2. **For best performance, ReliOn recommends the I-1000 should not be subjected to repeated or short term on/off cycles beyond 10 cycles. If a period of repeat run cycles is planned, the "On" time for each run cycle should be a minimum of 30 minutes.**

## Standards and Tolerances

| ***Parameter*** | ***Commissioning Procedure*** | ***Tolerance/Limit Initial Operating*** |
|---|---|---|
| 1. Bay 1 Cylinder Pressure ($P_1$) | 1 | 500-2200 psi |
| 2. Bay 1 Regulated Pressure ($P_2$) | 1 | 50 psi |
| 3. Bay 2 Cylinder Pressure ($P_3$) | 1 | 500-2200 psi |
| 4. Bay 2 Regulated Pressure ($P_4$) | 1 | 40 psi |
| 5. DC Bus Voltage ($V_{dc1}$) | 9 | ~ 27.3 Vdc |
| 6. DC Bus Voltage ($V_{dc2}$) | 9 | ~ 25.0 Vdc |
| 7. DC Bus Voltage ($V_{dc3}$) | 9 | > 26.75 Vdc |
| 8. Elapsed Time ($T_1$) | 9 | ~ 1 minute |
| 9. Elapsed Time ($T_2$) | 9 | ~ 2 minutes |
| 10. Elapsed Time ($T_3$) | 9 | ~ 6 minutes |
| 11. Elapsed Time ($T_4$) | 9 | ~ 20 minutes |
| 12. Maximum Current ($I_1$) | 9 | ~ 17 amps |